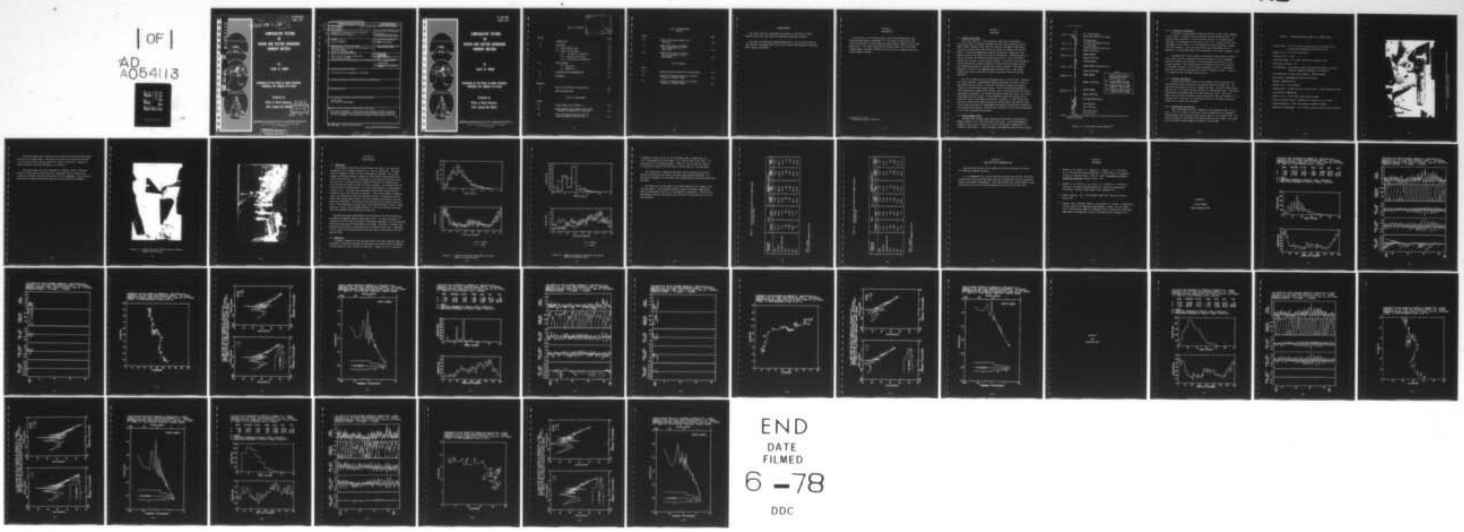
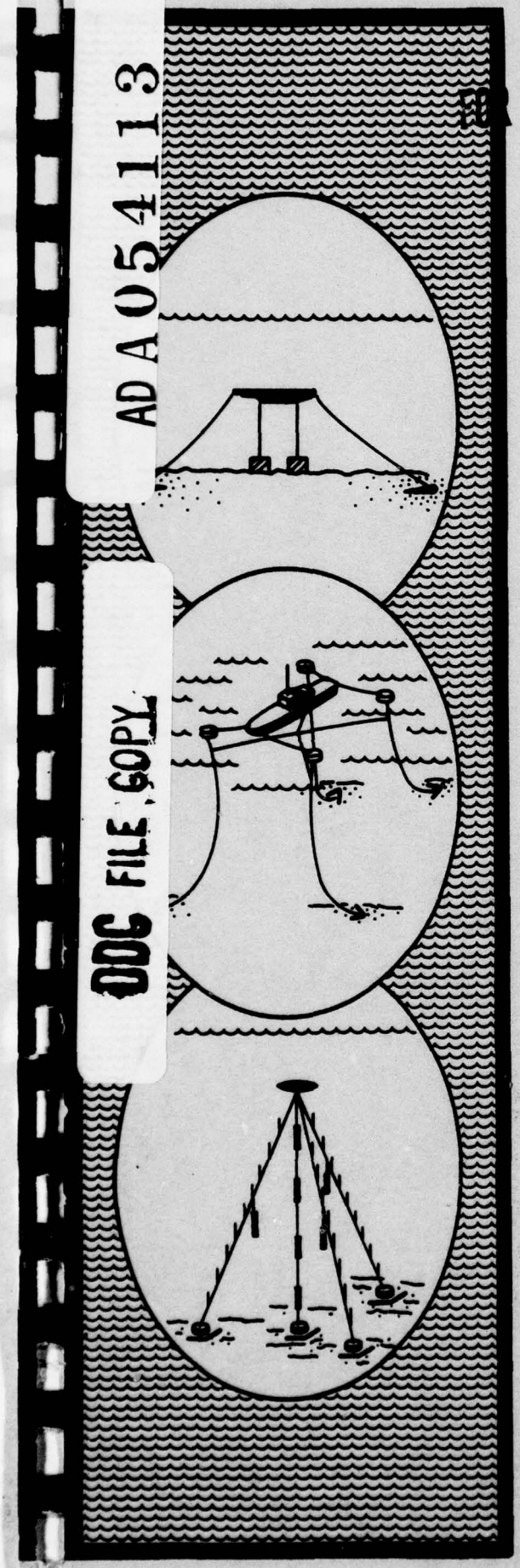
AD-A054 113 EG AND G WASHINGTON ANALYTICAL SERVICES CENTER INC R--ETC F/G 14/2
COMPARATIVE TESTING OF NISKIN AND VECTOR AVERAGING CURRENT METE--ETC(U)
APR 78 L W BONDE
UNCLASSIFIED EG/G-TR-4618-0001 N00014-74-C-0146
NL

| OF |
AD
A054113



END
DATE
FILMED
6 -78
DDC



TR 4618-0001
APRIL 1978

FOR FURTHER TRAN

COMPARATIVE TESTING OF NISKIN AND VECTOR AVERAGING CURRENT METERS

By

LESLIE W. BONDE

SPONSORED BY THE OFFICE OF NAVAL RESEARCH
CONTRACT NO. N00014-74-C-0146

Prepared for

Office of Naval Research
NSTL Station MS 39529

EG&G WASHINGTON ANALYTICAL SERVICES CENTER, INC.
2150 FIELDS ROAD ROCKVILLE, MARYLAND 20850
TEL. (301) 840-3000

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: EG&G-TR-4618-0001	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Comparative Testing of Niskin and Vector Averaging Current Meters.	5. TYPE OF REPORT & PERIOD COVERED: Technical Rept'g
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Leslie W. Bonde	8. CONTRACT OR GRANT NUMBER(s): N00014-74-C-0146
9. PERFORMING ORGANIZATION NAME AND ADDRESS: EG&G Washington Analytical Services Center, Inc. 2150 Fields Road Rockville, Maryland 20850	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Office of Naval Research (Code 485) NSTL Station, MS 39529	12. REPORT DATE: Apr 1978
	13. NUMBER OF PAGES: 48 (22 47P.)
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution of this document is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Current Meter
Water Velocity Measurement

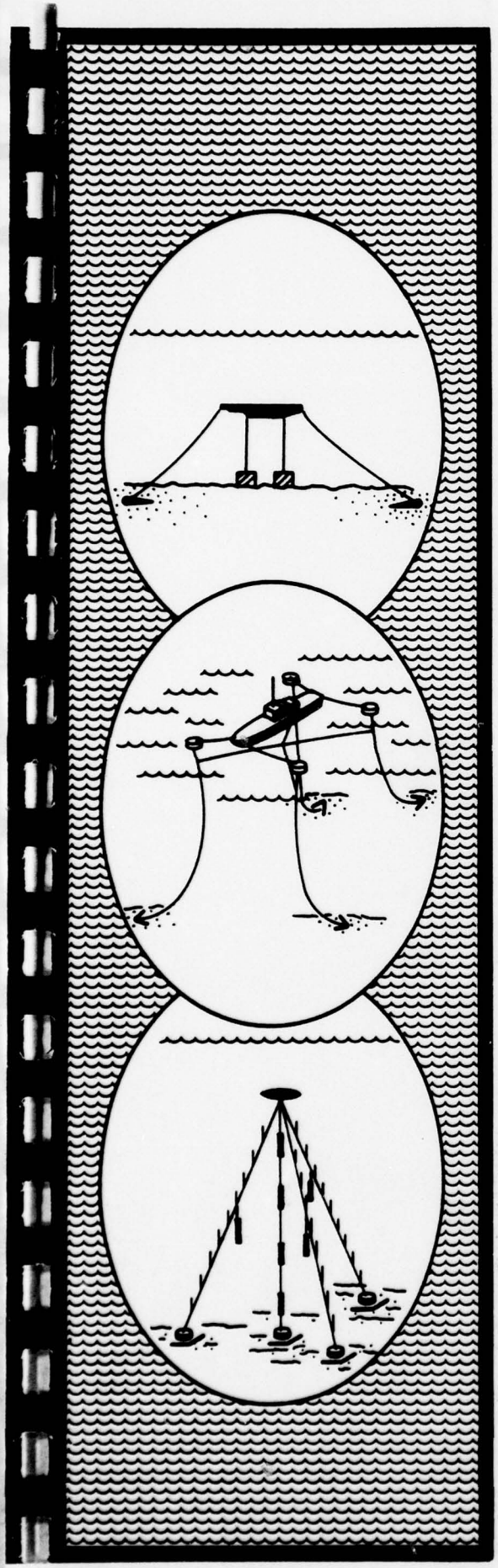
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents a current meter array composed of Niskin and Vector Averaging Current Meters, the data acquired and the results of comparing the two instruments. Data acquired by adjacent meters compared favorably.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

TR 4618-0001
APRIL 1978



COMPARATIVE TESTING OF NISKIN AND VECTOR AVERAGING CURRENT METERS

By

LESLIE W. BONDE

SPONSORED BY THE OFFICE OF NAVAL RESEARCH
CONTRACT NO. N00014-74-C-0146

Prepared for

Office of Naval Research
NSTL Station MS 39529

EG&G WASHINGTON ANALYTICAL SERVICES CENTER, INC.
2150 FIELDS ROAD ROCKVILLE, MARYLAND 20850
TEL. (301) 840-3000

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS
(cont'd)

LIST OF TABLES

ACKNOWLEDGMENTS

The author wishes to acknowledge the support of the Office of Naval Research, Code 485, which made the comparison experiment possible.

The Niskin and VACM data summaries (Appendices A and B) were provided by David Halpern and Hugh Milburn of the Pacific Marine Environmental Laboratory, NOAA, Seattle, Washington.

SECTION I
INTRODUCTION

As an adjunct to the Joint Office of Naval Research/NOAA Data Buoy Office Mooring Dynamics Experiment[1]*, two Niskin current meters were installed adjacent to Vector Averaging Current Meters (VACM) on the current meter array. This report describes the current meter array, the Niskin current meters, the data acquired, and the results of comparing the Niskin current meters and VACM.

* References listed in Section V.

SECTION II
EXPERIMENT

2.1 CURRENT METER ARRAY.

The array, Figure 2-1, was designed by Woods Hole Oceanographic Institution (WHOI) to measure currents with five Vector Averaging Current Meters (VACM) located at 200, 500, 750, 1000 and 1300 meters water depth. Two Niskin current meters were placed just below the VACMs at 201 and 752 meters. A precision temperature pressure recorder was located near the sphere to monitor the depth of the top of the mooring. The design depth of the top flotation was 165 meters below the surface in order to minimize motions due to waves and near surface currents. Glass balls were attached to the mooring above the anchor releases as a backup mooring recovery system. This permitted recovery of the mooring or mooring remains in the event of mechanical failure of any component above the glass balls. Dual anchor releases were used in parallel to provide increased reliability through redundancy.

The array's mooring line was torque-balanced 3 x 19 wire rope. The glass balls were enclosed in polyethylene hardhats and bolted to 0.95 cm (3/8 in) galvanized proof coil chain. Chain was used below and above the acoustic releases to prevent chafe during launch. Nylon line below the release provided compliance to reduce shock loading, since a free drop anchor last type of deployment was employed. The anchor consisted of used chain cast in concrete, and weighed 1360 kg in water. A 20 kg Danforth anchor was attached to the clump with chain to increase the horizontal resistance. A rope braided from polyvinyl alcohol (PVA) sheets was used to bind the chain and Danforth anchor to the clump to prevent its entanglement and possible chafing with the mooring line during anchor descent. The PVA rope is soluble in water and disintegrated in four hours releasing the Danforth.

2.2 NISKIN CURRENT METER.

Two Model 6011 cassette tape recording current meters, manufactured by General Oceanics, Inc., were installed on the array. In the oceanographic community, this device is known as a Niskin current meter, named after it's inventor, Shale Niskin. In this document, the community name will be utilized.

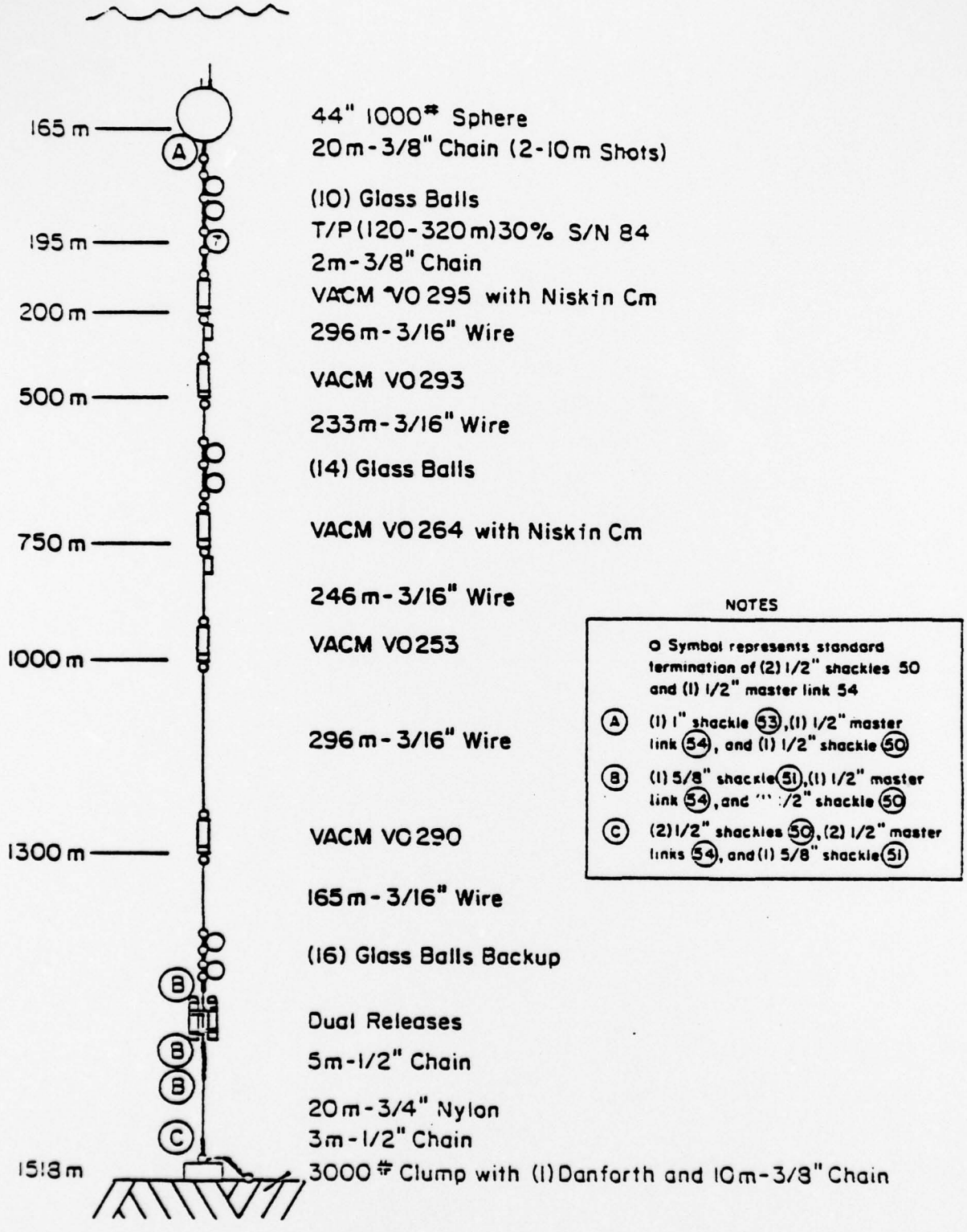


Figure 2-1. Current Meter Array Schematic[2]

2.2.1 Principles of Operation.

The Niskin current meter is negatively buoyant so that, when suspended in still water, it hangs vertically downward from the mounting swivel. Any current causes the meter to incline from the vertical in the down-current direction. The magnitude and direction of this tilt is measured within the instrument by four sensors - an inclinometer and three orthogonally mounted Hall effect devices. Each Hall effect device has the property that it generates a voltage proportional to the component of the earth's magnetic field.

Readings from all four sensors are recorded at each sampling interval. Then, during the data reduction process after recovery of the instrument, these four readings are combined, and the magnitude and direction of the current computed. The direction must be corrected for the local variation in the earth's magnetic field to obtain geographic direction. Reference 3 describes the operation and specifics of the instrument in detail. Table 2-1 is a summary of the instrument specifications.

2.2.2 Checkout and Startup.

Prior to installation, each unit was removed from its pressure case and inspected, battery connected, and cassette installed (Figure 2-2). The sampling rate was set for four (4) readings per hour. The burst sample rotors were set for a 2.6 second interval and four (4) readings per burst. Units were synchronized to Greenwich Mean Time (GMT) and clocks reset. Each unit's manual step switch was actuated to verify operability and then installed in it's pressure case. Just prior to installation, each unit's external switch was turned on to activate the instrument.

2.2.3 Installation and Recovery.

The current meter array was installed in the northwest corner (22° 12' N Lat., 159° 57' W Long.) of the Pacific Missile Range Facility, Underwater Tracking Range, west of Barking Sands, Kauai, Hawaii, on 11 October 1976. The implant was made in 1518 meter water depth by the free drop anchor last method from the USNS DE STEIGER (AGOR) by personnel from the WHOI.

TABLE 2-1. SPECIFICATIONS FOR MODEL 6011 CURRENT METER

- Current Range: 0 to 3-1/2 knots; sensitivity may be shifted to low or high end by changing weight and fin size.
- Range of Tilt: 0° to 90° from vertical
- Accuracy of Tilt: ±1/2°
- Directional Range: 0° to 360° referenced to magnetic north
- Directional Accuracy: ±1°
- Time Reference: Solid-state crystal controlled oscillator; ±5 sec/day accuracy; operating frequency of 18.641 kHz
- Data Recording: Philips style cassette; 20,000 readings
- Data Format: Complementary binary on two tracks
- Battery: Welded AA cells
- Battery Life: 6 to 12 months
- Sampling Rate: 10 position switch selects from 1 to 512 readings per hour
- Depth Rating: 6000 meters
- Weight in Air: 10 lbs with 6 month battery supply
- Size of Pressure Casting: Diameter 4 in, Length 14 in (w/o fins)
- Exposed Materials: Plastic and hardcoat anodized aluminum
- Operational Temperature: -5°C to +45°C; accuracy ±1/64°C with calibration

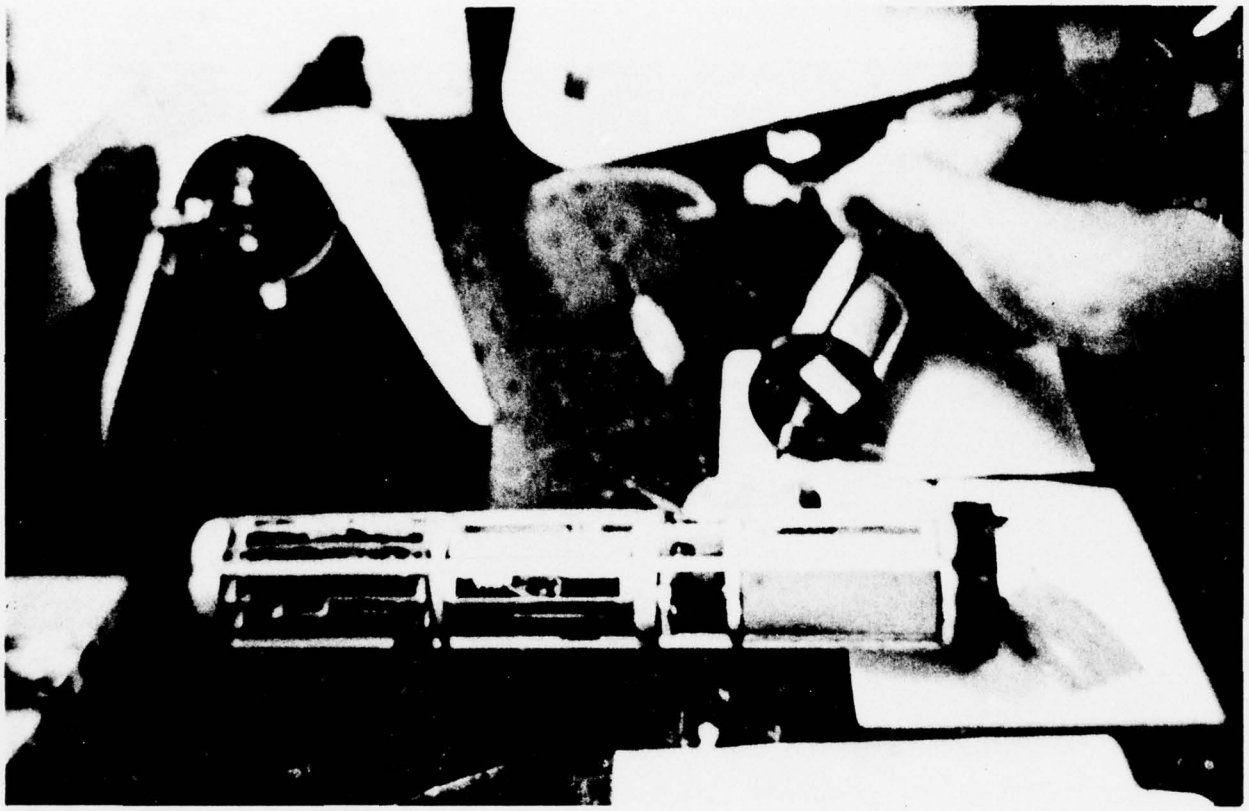


Figure 2-2. Niskin Removed from Pressure Case, Being Inspected, and Readied for Deployment

The Niskin meters were installed on the array with SN-9 at 201 meter depth and SN-14 at 752 meter depth. Each meter was secured to the mooring line with a wire stop and plastic mooring standoff as shown in Figure 2-3. Figure 2-4 shows the meters installed and ready to go overboard.

The current meter array was recovered on 2 November 1976 by firing the acoustic release which allowed the array's subsurface float to come to the surface for recovery along with the balance of array components. Once on board, each Niskin's external switch was turned off to deactivate the instrument.

Figure 2-3. Niskin Installed on Mooring Line via Mooring Standoff and Wire Stop

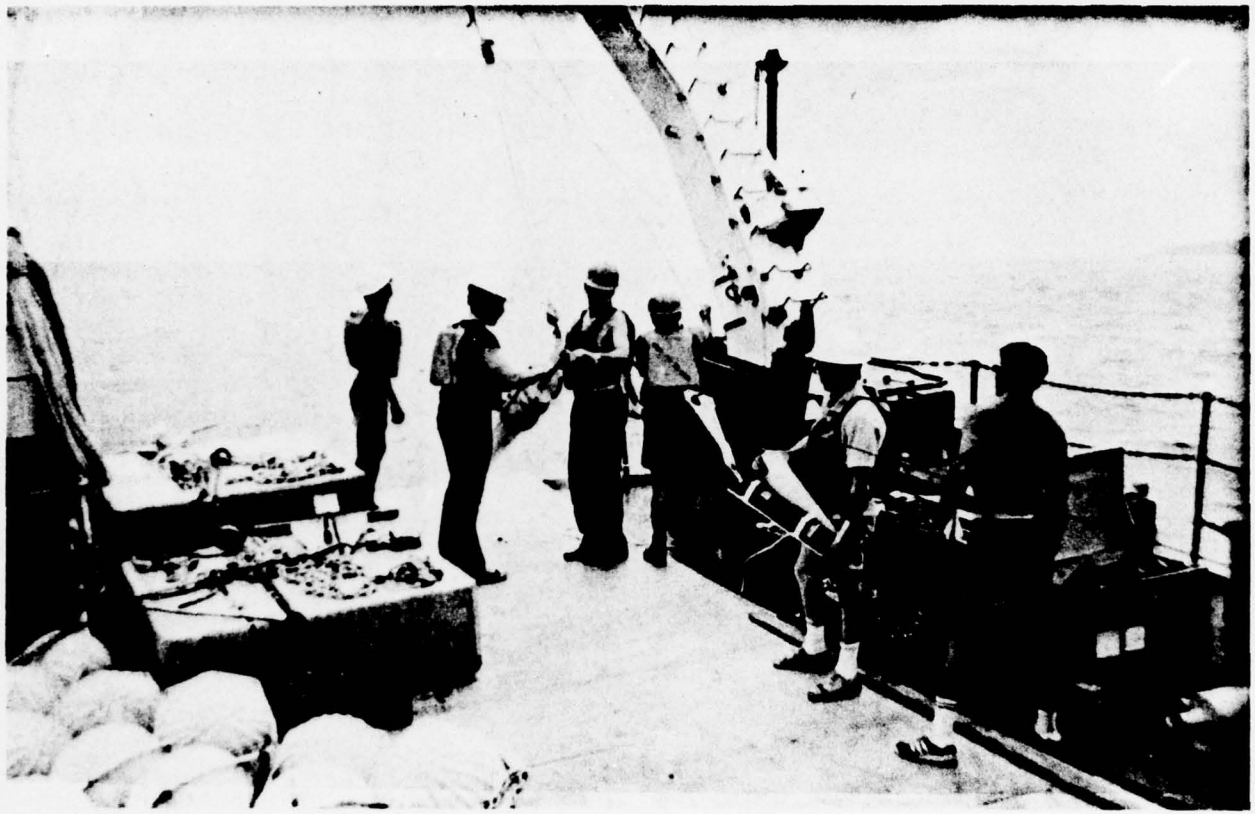


Figure 2-4. Niskin Installed and Ready to Go Overboard

SECTION III
DATA ACQUIRED

3.1 PROCESSING.

Upon receipt of the Niskin current meters from Hawaii, the tapes were removed and sent to General Oceanics, Inc. (GO) for processing. An analog trace and computer listing for each instrument was provided. The listing showed a significant number of negative current periods (approximately 20% of the total readings). This was brought to the attention of GO, who stated that the unit's trim might be off, thereby introducing this negative bias. The units were returned to GO for salt water trimming. GO indicated that the units trim was off approximately 1 bit which would account for approximately 5 cm/sec error. The tapes were reprocessed, taking into account the trim correction, and a new listing was supplied. This listing showed no negative values, but essentially halved all preceeding values. Having data from the VACMs, this current speed reduction was not accepted and discussions with GO were again undertaken. GO indicated that they had used the wrong calibration curve. They reprocessed the data again, and furnished another listing. Based upon this listing, which appeared plausable, a nine track tape was furnished by GO for standard current meter data processing.

The VACM data taken simultaneously with the Niskins had been processed by the NOAA Environmental Research Laboratories (ERL). In order to prevent introduction of errors due to variance in processing techniques, ERL also processed the Niskin tape using the same method as the VACMs. Reference 4 documents the method utilized by ERL in processing both the VACM and Niskin data. Appendices A and B contain the processed data for the two Niskin current meters and their adjacent VACM.

3.2 COMPARISON.

In order to compare the data from the Niskins with their adjacent VACM, the histograms of speed and direction for both meters have been scaled and combined into one figure for each location on the array. Figures 3-1 and 3-2 show the

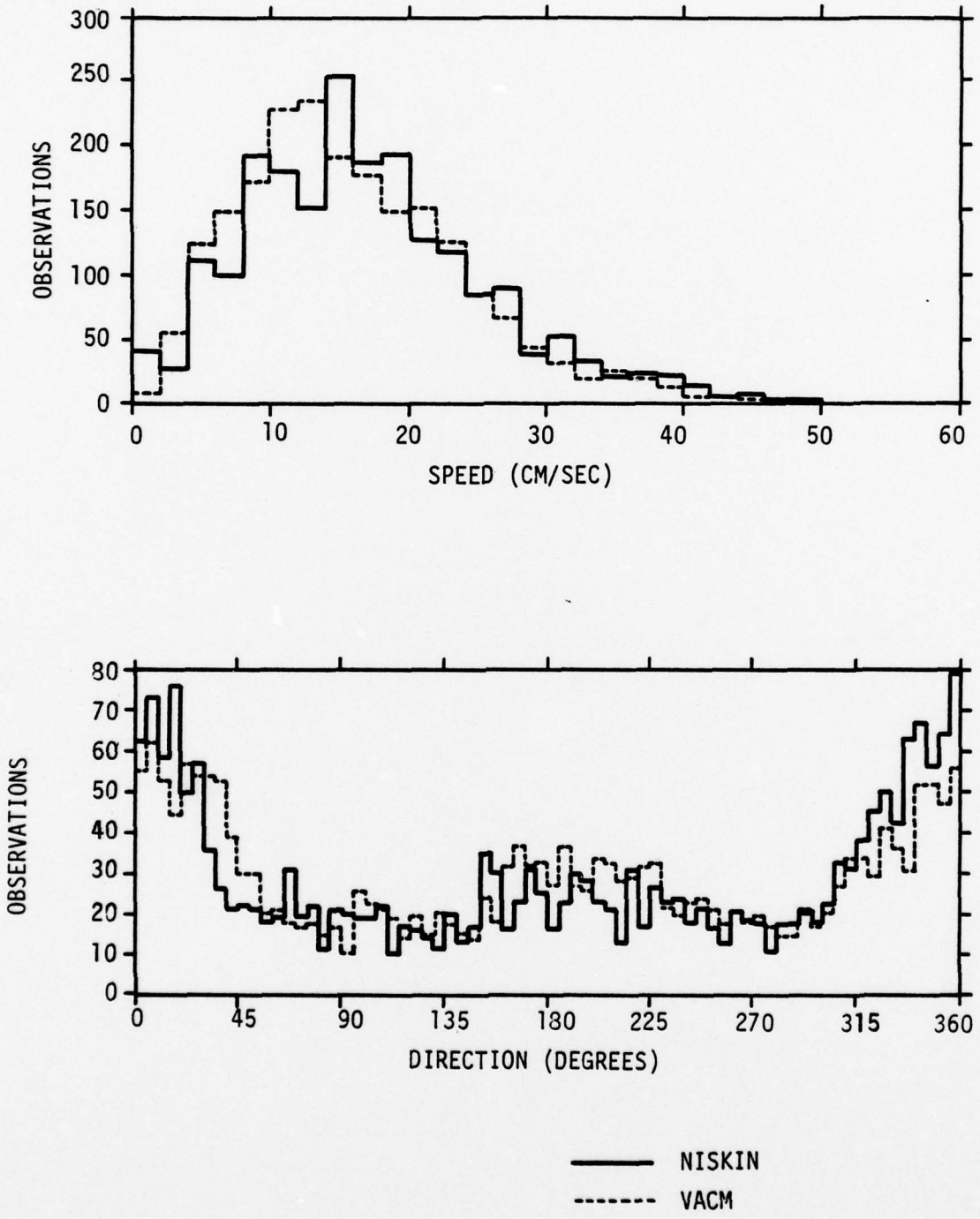


Figure 3-1. Speed and Direction Histograms for Current Meters at 201 Meter Depth

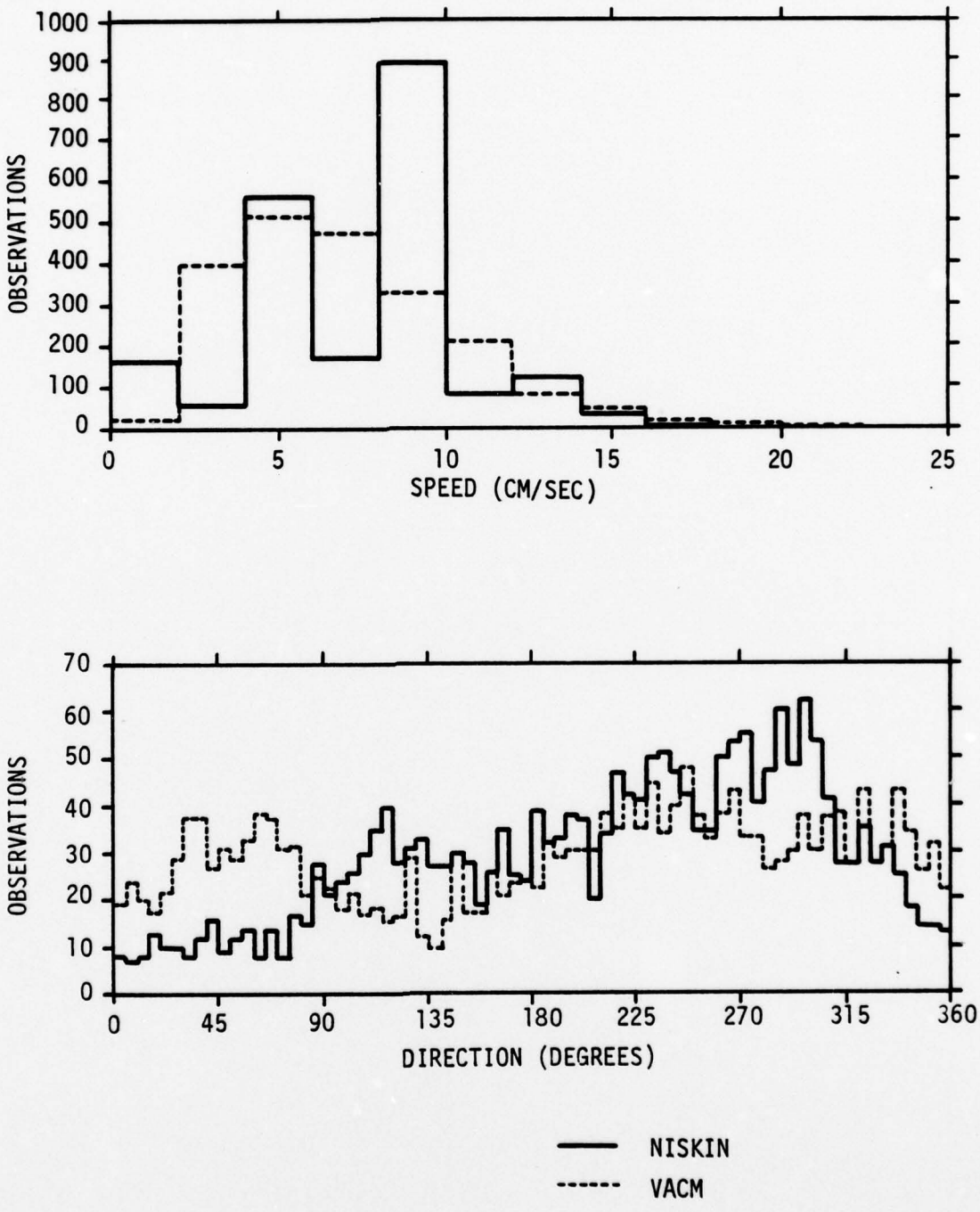


Figure 3-2. Speed and Direction Histograms for Current Meters at 752 Meter Depth

histograms for each unit at 201 and 752 meters depth, respectively, for a 21.7 day observation period (0200, 12 Oct 1976 to 1945, 2 Nov 1976). All observations are 15 minute averages. Tables 3-1 and 3-2 show the results of statistical analysis for each type of current meter for the two depths.

The histograms for speed and direction, and the statistical analysis results for the Niskin and VACM at 201 meter depth compare favorably. All statistical parameters for the Niskin were approximately 10 percent greater than the VACM.

The comparison for the meters at 752 meter depth was not as good as the shallower meters. The histograms showed a larger difference, sometimes as great as 300 percent variation, in the number of observations. Statistically, they compare good, but the results are not biased in one direction as in the shallow meters.

TABLE 3-1. STATISTICAL ANALYSIS RESULTS FOR CURRENT METERS AT 201 METER DEPTH

STATISTICAL PARAMETER	SPEED		COMPONENT OF VELOCITY			
			EAST -- WEST		NORTH -- SOUTH	
	NISKIN	VACM	NISKIN	VACM	NISKIN	VACM
Mean	17.18	15.99	-1.69	-1.11	4.56	3.03
Variance	83.72	66.50	113.52	102.86	241.69	208.77
Standard Deviation	9.15	8.15	10.65	10.14	15.55	14.45
Skew	.901	.749	-.549	-.430	-.250	-.174
Kurt	4.049	3.530	3.533	3.001	3.141	2.836
Max.	59.03	53.37	29.17	28.16	58.90	53.31
Min.	.41	.55	-50.43	-43.00	-42.95	-38.88

Units = cm/sec
East and North Component Positive

TABLE 3-2. STATISTICAL ANALYSIS RESULTS FOR CURRENT METERS AT 752 METER DEPTH

STATISTICAL PARAMETER	SPEED		COMPONENT OF VELOCITY			
			EAST — WEST		NORTH — SOUTH	
	NISKIN	VACM	NISKIN	VACM	NISKIN	VACM
Mean	7.53	6.90	-1.89	-.78	-1.41	.38
Variance	9.01	10.00	34.55	28.67	25.56	28.17
Standard Deviation	3.00	3.16	5.88	5.35	5.06	5.31
Skew	.468	.829	.391	.135	-.180	.125
Kurt	4.709	3.675	2.486	2.612	2.685	2.866
Max.	23.17	20.78	19.46	13.84	9.67	18.17
Min.	.85	.13	-19.00	-20.73	-22.78	-15.64

Units - cm/sec
East and North Component Positive

SECTION IV
CONCLUSION AND RECOMMENDATIONS

Based upon the results of the comparative testing conducted, the Niskin and VACM data compared favorably.

It is recommended that a data processing system be developed for the Niskin current meter which could take tapes from the instrument and provide statistical analysis and graphic presentation. Users must specify the current velocity range anticipated, since the fin design employed varies with the current range.

SECTION V
REFERENCES

1. Walden, R. G., DeBok, D. H., Meggitt, D., Gregory, J. B., and Vachon, W. A., "The Mooring Dynamics Experiment - A Major Study of the Dynamics of Buoys in the Deep Ocean," Paper No. 2883, Proceedings of Offshore Technology Conference, Houston, Texas, 1977.

2. Walden, R. G., Collins, C. W., Clay, P. R., O'Malley, P., "Validation Testing of the DOCMS Intermediate Mooring," Woods Hole Oceanographic Institution, Technical Report WHOI-77-53, September 1977.

3. General Oceanics, Inc., "Current Meter Model 6011 Instruction Manual," August 1976.

4. Halpern, David, Holbrook, James R., and Reynolds, R. Michael, "A Compilation of Wind, Current and Temperature Measurements: Oregon, July and August 1973", CUEA Technical Report 6, Reference M74-73, University of Washington, Department of Oceanography, Seattle, Washington 98195, September 1974.

APPENDIX A

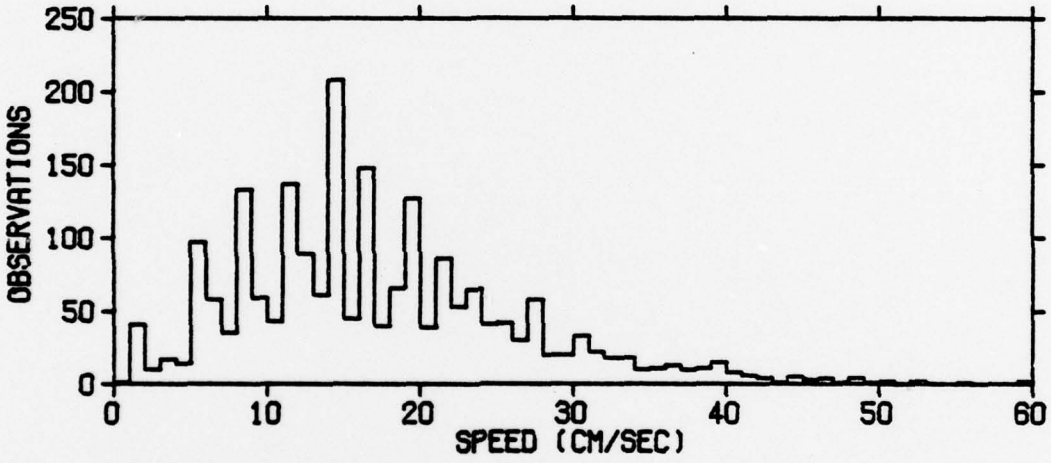
NISKIN CURRENT

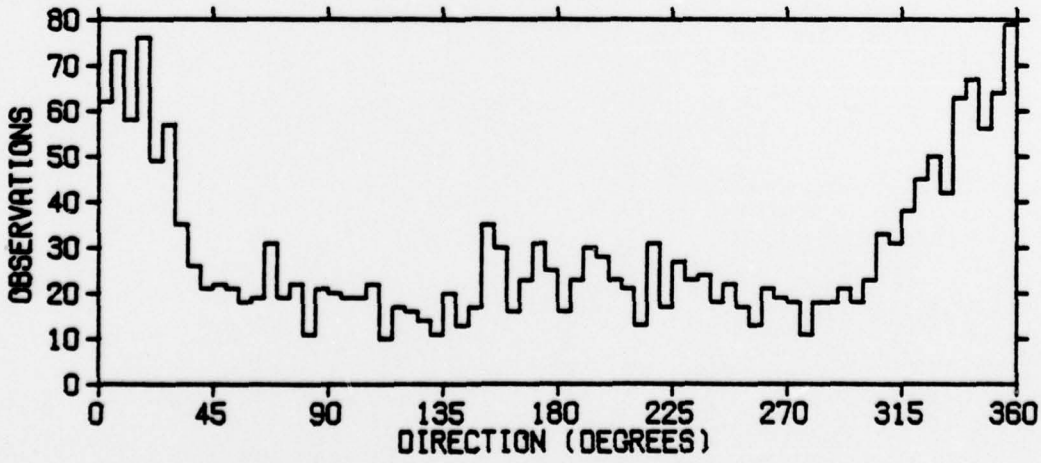
METER PROCESSED DATA

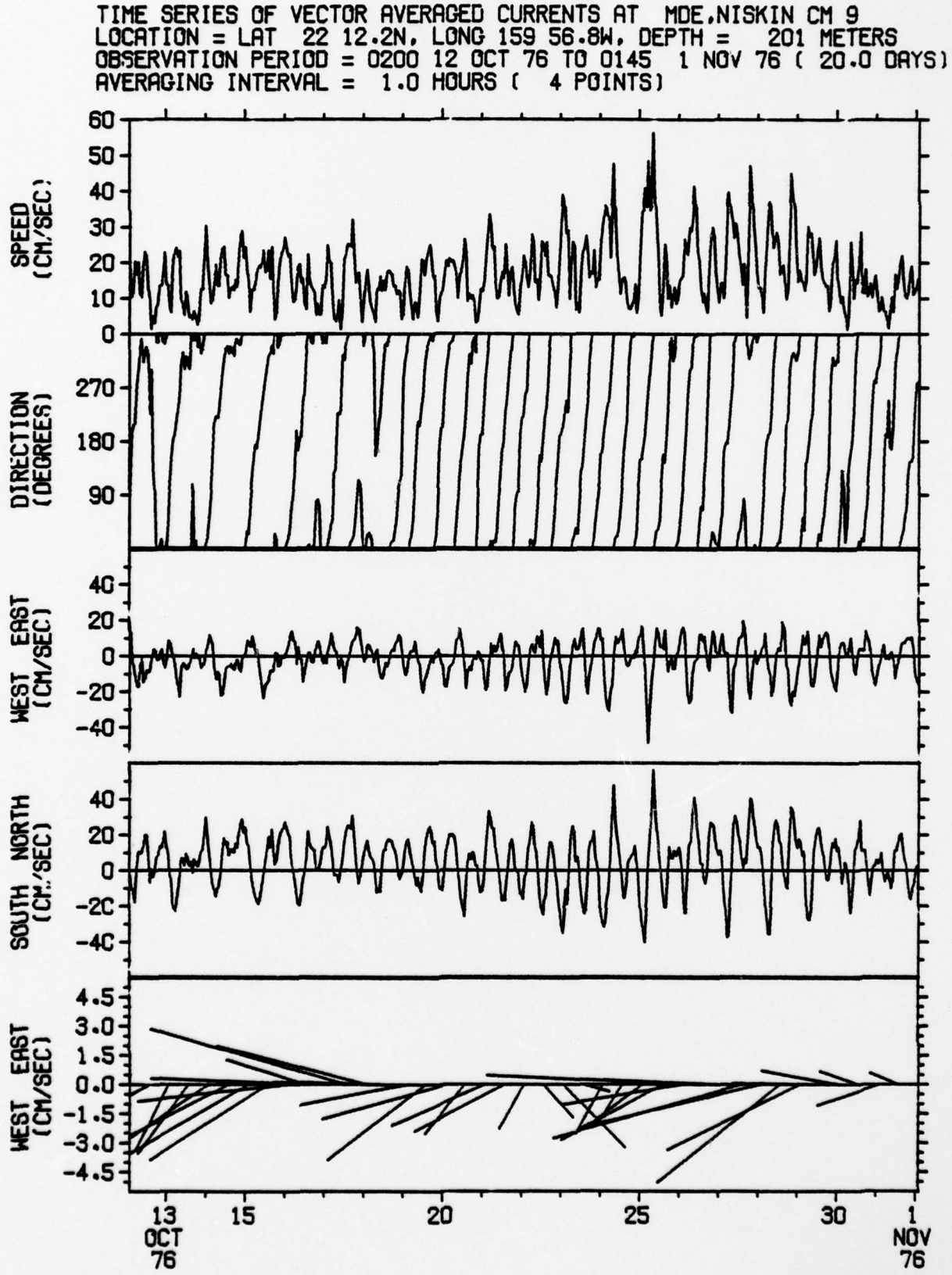
STATISTICS AND HISTOGRAMS OF CURRENTS AT MDE,NISKIN CM 9
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 201 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
N = 2088, DT = 15.00 MINUTES, UNITS = (CM/SEC)

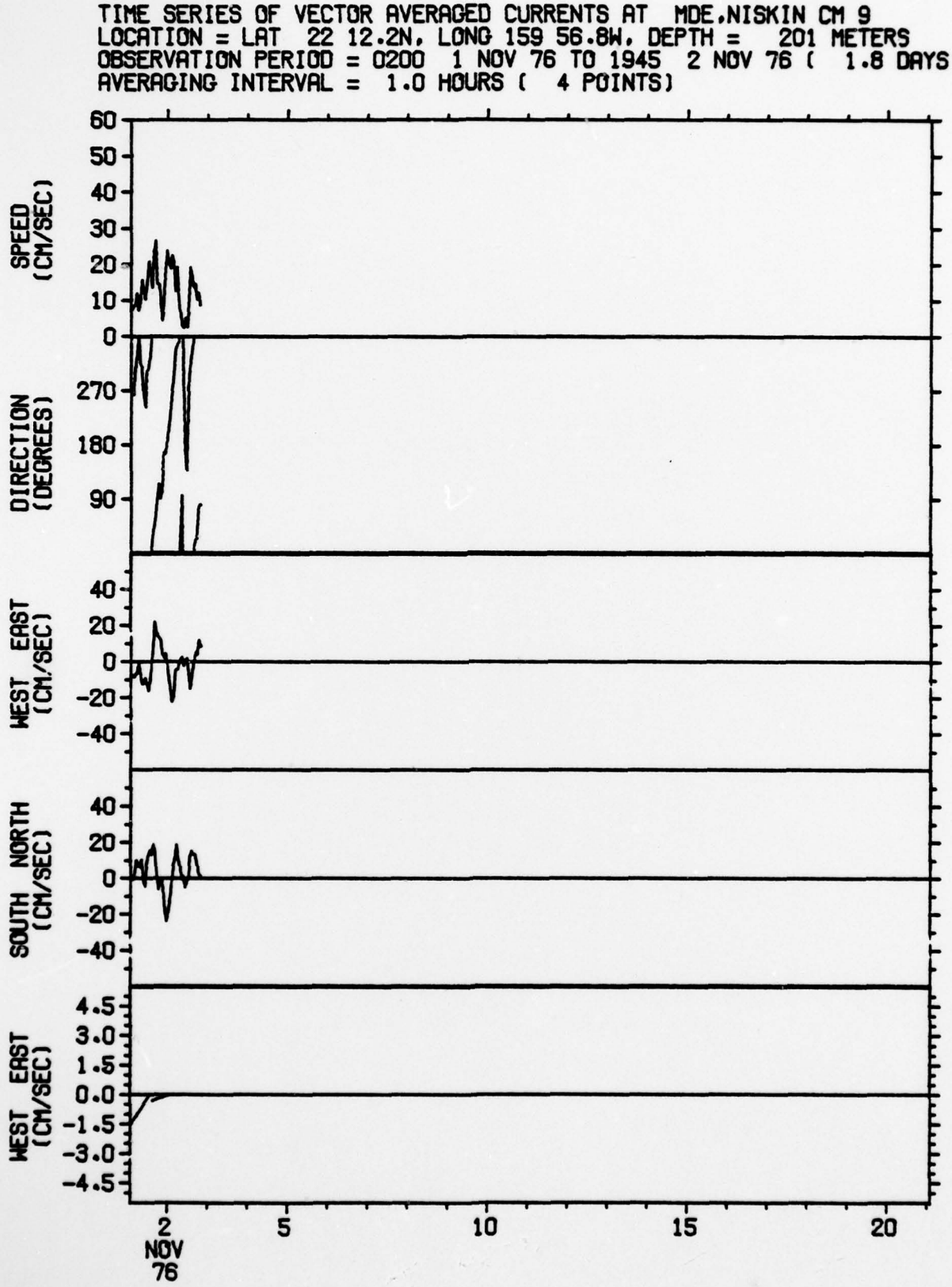
	MEAN	VARIANCE	ST-DEV	SKEW	KURT	MAX	MIN
S	17.18	83.72	9.15	.901	4.049	59.03	.41
U	-1.69	113.52	10.65	-.549	3.533	29.17	-50.43
V	4.56	241.69	15.55	-.250	3.141	58.90	-42.95

S = SPEED
U = EAST-WEST COMPONENT OF VELOCITY, EAST = POSITIVE U
V = NORTH-SOUTH COMPONENT OF VELOCITY, NORTH = POSITIVE V

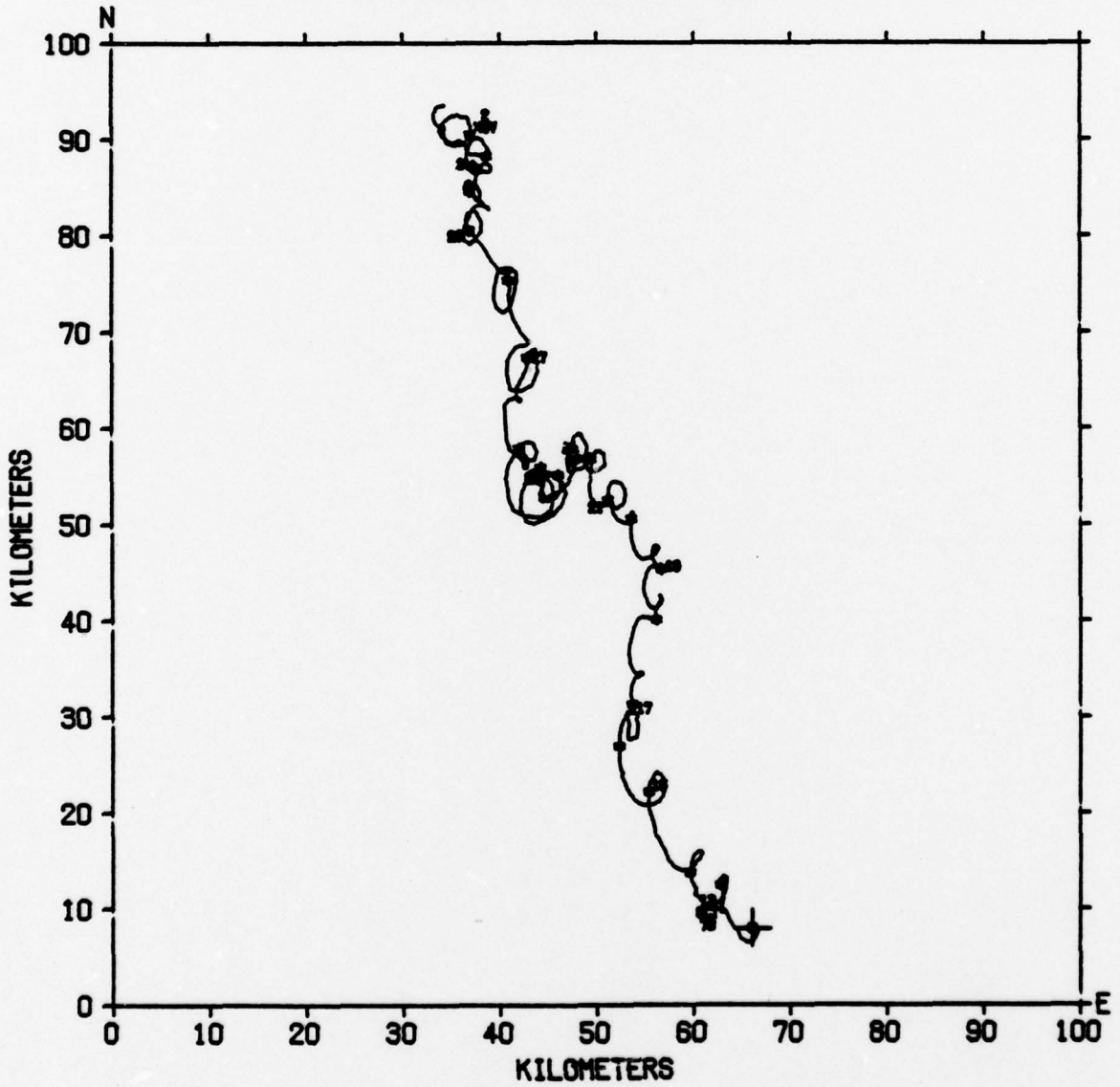




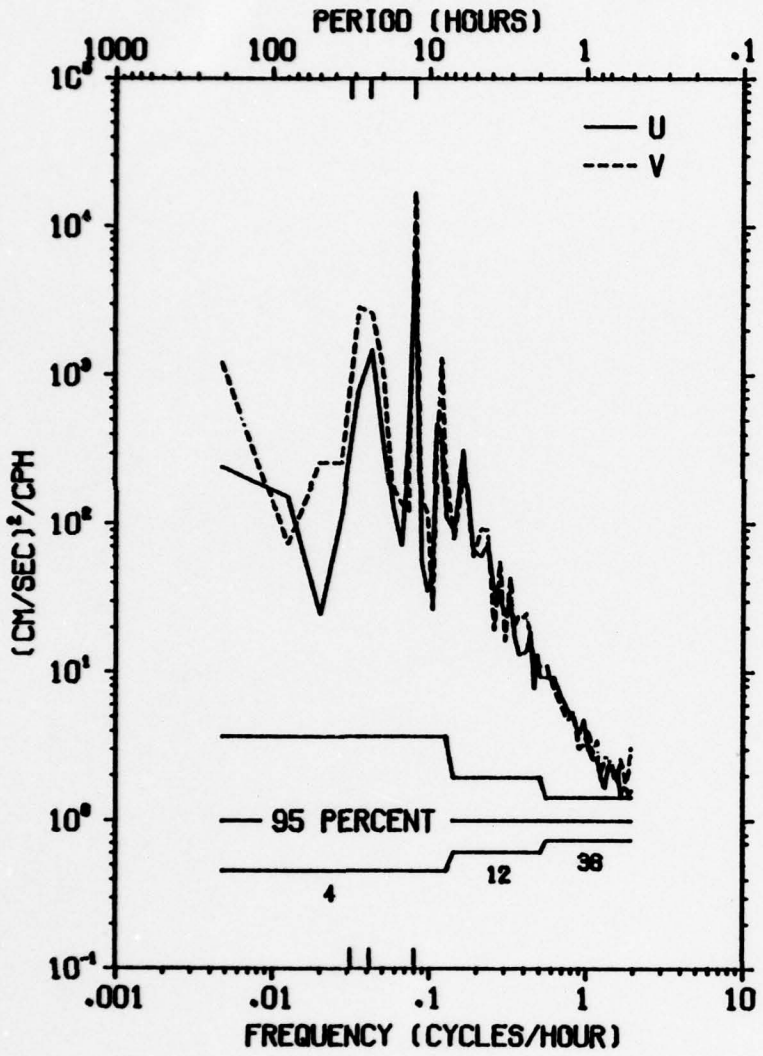

TIME SERIES OF VECTOR AVERAGED CURRENTS AT MDE,NISKIN CM 9
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 201 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 0145 1 NOV 76 (20.0 DAYS)
AVERAGING INTERVAL = 1.0 HOURS (4 POINTS)
SPEED (CM/SEC)
60
50
40
30
20
10
0
DIRECTION (DEGREES)
270
180
90
WEST EAST (CM/SEC)
40
20
0
-20
-40
SOUTH NORTH (CM/SEC)
40
20
0
-20
-40
WEST EAST (CM/SEC)
4.5
3.0
1.5
0.0
-1.5
-3.0
-4.5
13
OCT
76
15
20
25
30
1
NOV
76

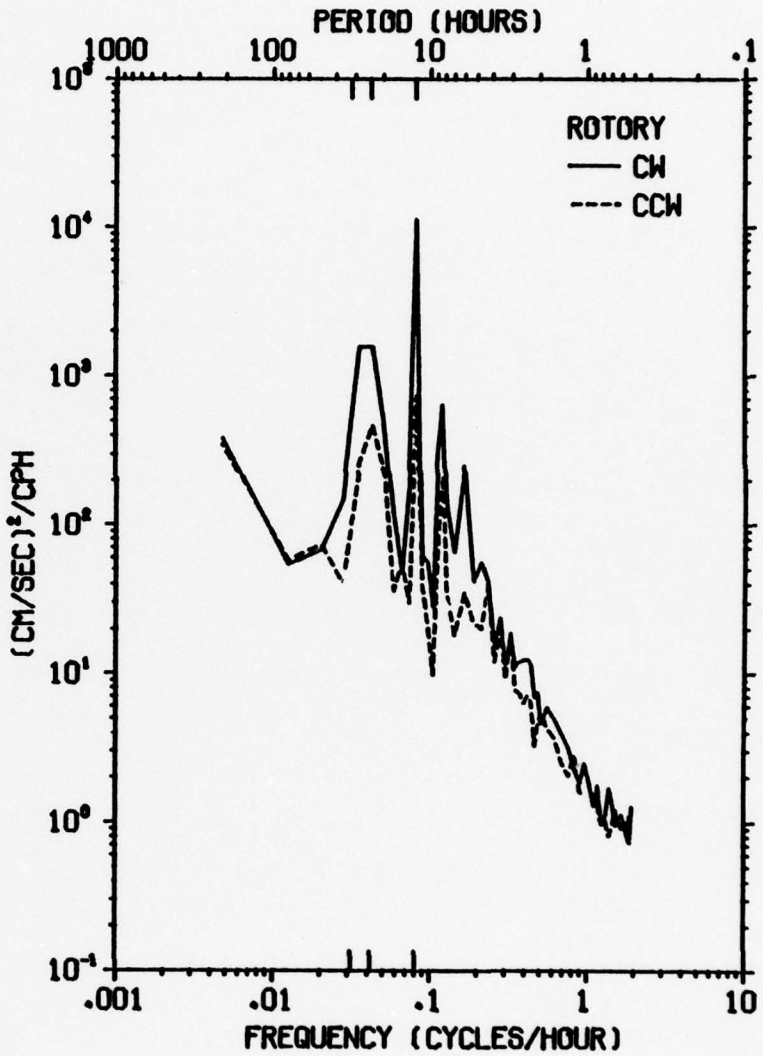

TIME SERIES OF VECTOR AVERAGED CURRENTS AT MDE.NISKIN CM 9
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 201 METERS
OBSERVATION PERIOD = 0200 1 NOV 76 TO 1945 2 NOV 76 (1.8 DAYS)
AVERAGING INTERVAL = 1.0 HOURS (4 POINTS)
SPEED (CM/SEC)
60
50
40
30
20
10
0
DIRECTION (DEGREES)
270
180
90
WEST EAST (CM/SEC)
40
20
0
-20
-40
SOUTH NORTH (CM/SEC)
40
20
0
-20
-40
WEST EAST (CM/SEC)
4.5
3.0
1.5
0.0
-1.5
-3.0
-4.5
2
NOV
76
5
10
15
20

PROGRESSIVE VECTOR DIAGRAM OF CURRENTS AT MDE,NISKIN CM 9
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 201 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
* EVERY 1.0 DAYS BEGINNING AT 0000 13 OCT 76

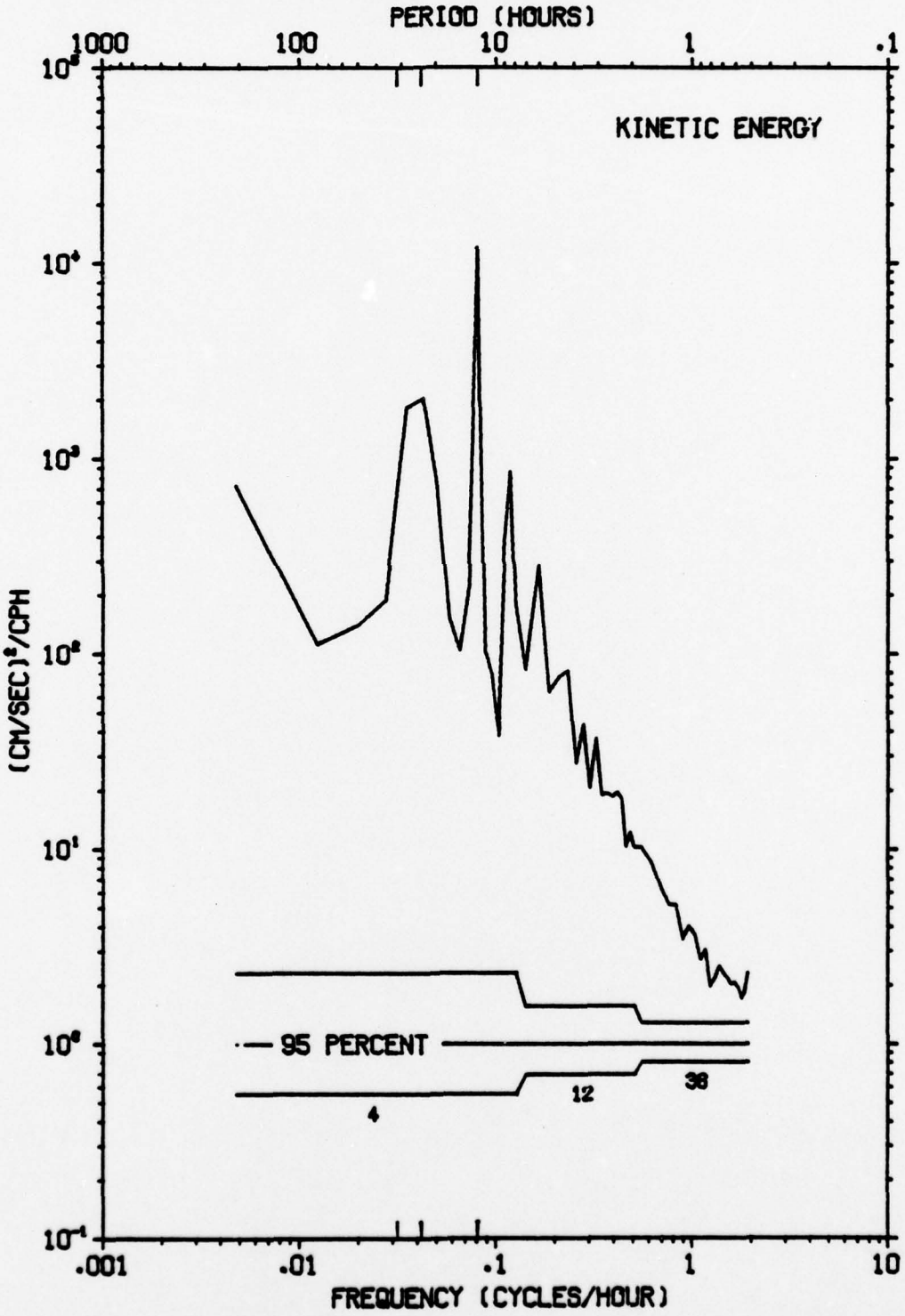


U, V AND ROTORY SPECTRA OF CURRENTS AT MDE,NISKIN CM 9
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 201 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
N = 2088, DT = 15.00 MINUTES, SMOOTHING - DANIELL WINDOW





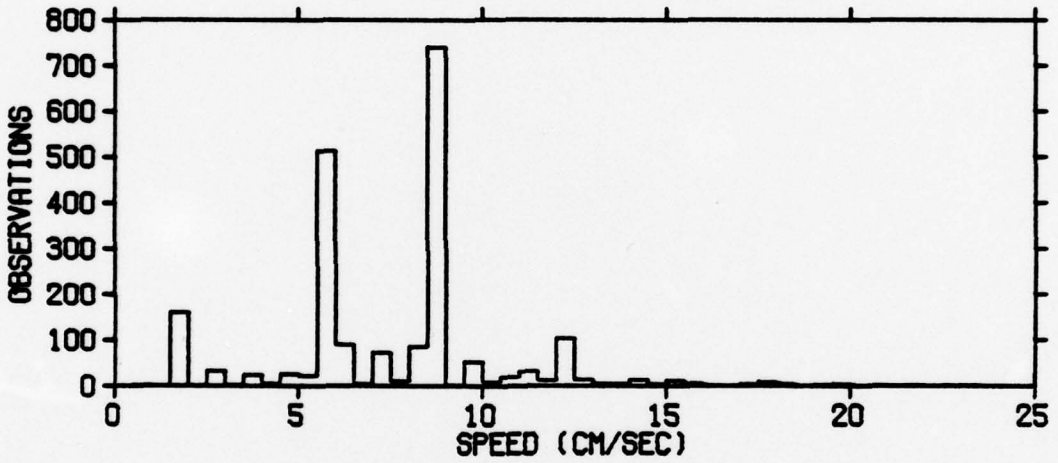
KINETIC ENERGY SPECTRUM OF CURRENTS AT MDE,NISKIN CM 9
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 201 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
N = 2088, DT = 15.00 MINUTES, SMOOTHING - DANIELL WINDOW

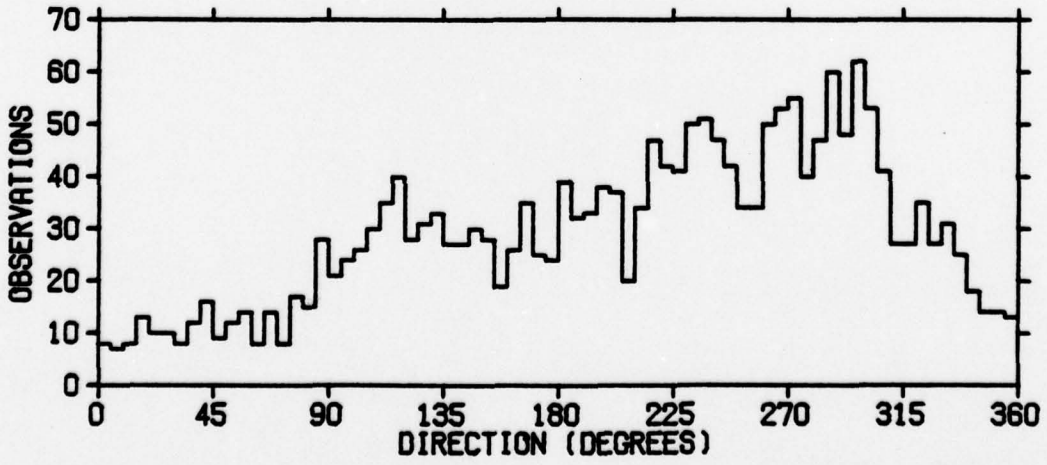


STATISTICS AND HISTOGRAMS OF CURRENTS AT MDE,NISKIN CM 14
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 752 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
N = 2088, DT = 15.00 MINUTES, UNITS = (CM/SEC)

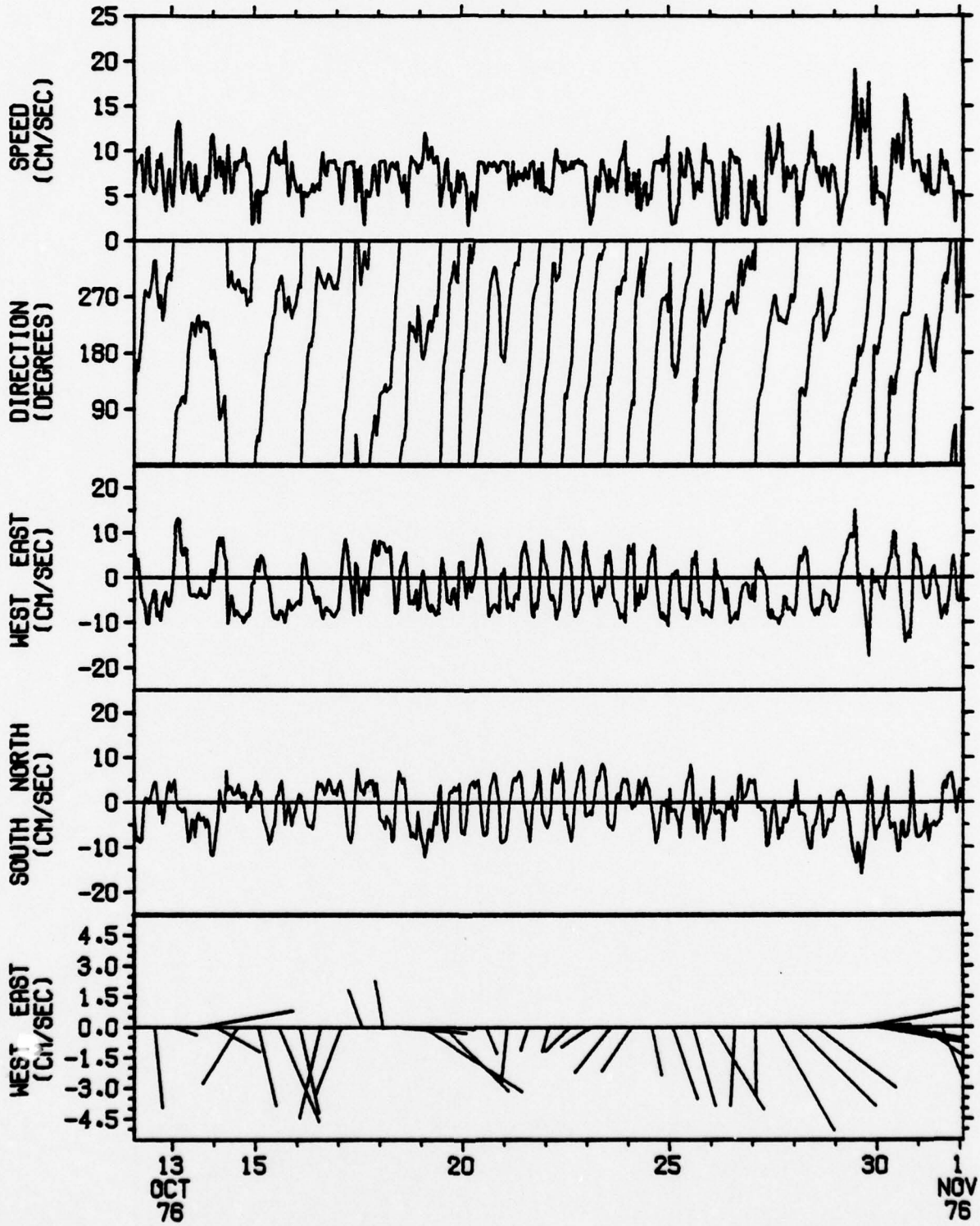
	MEAN	VARIANCE	ST-DEV	SKEW	KURT	MAX	MIN
S	7.53	9.01	3.00	.468	4.709	23.17	.85
U	-1.89	34.55	5.88	.391	2.486	19.46	-19.00
V	-1.41	25.56	5.06	-.180	2.685	9.67	-22.78

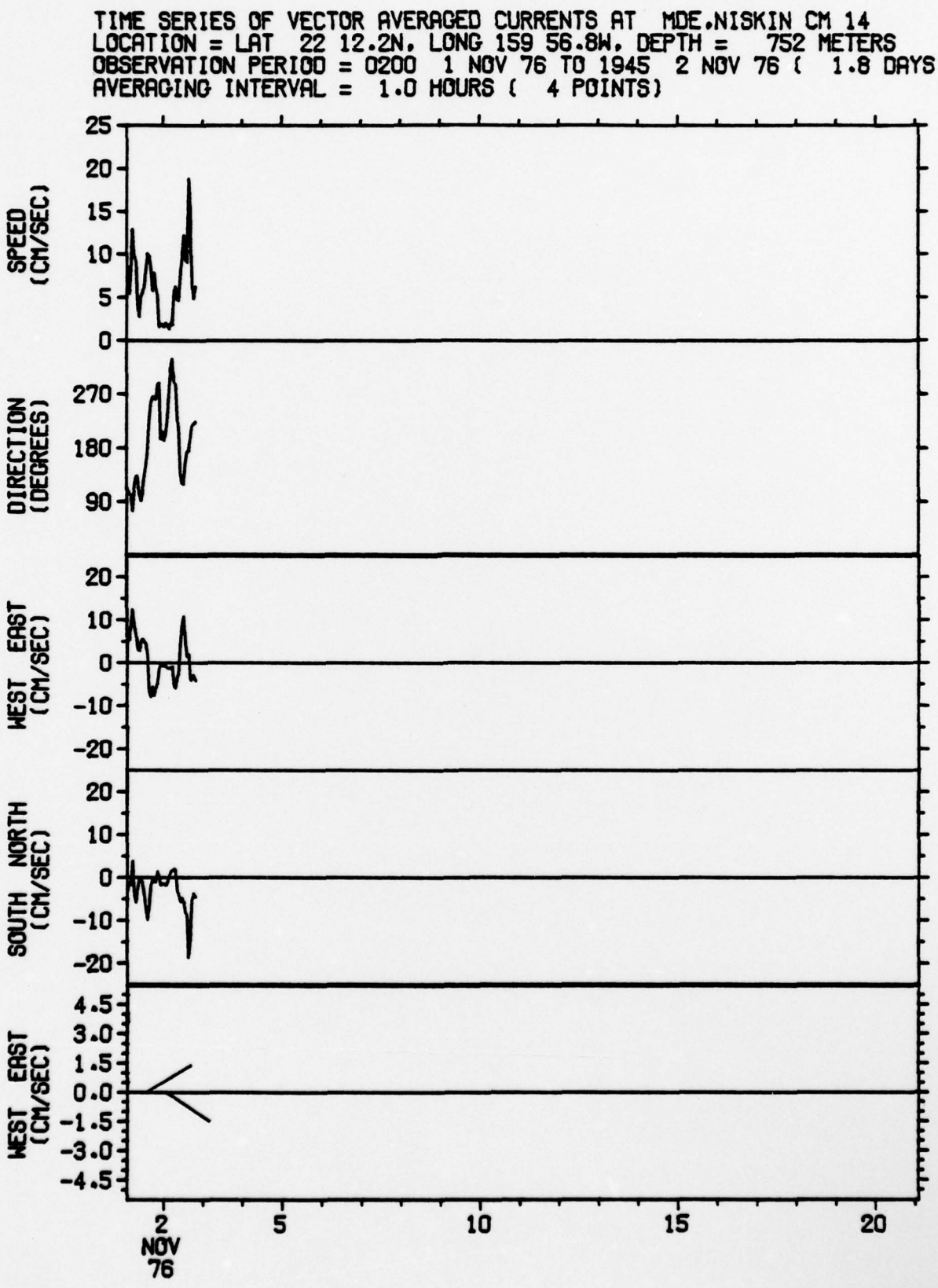
S = SPEED
U = EAST-WEST COMPONENT OF VELOCITY, EAST = POSITIVE U
V = NORTH-SOUTH COMPONENT OF VELOCITY, NORTH = POSITIVE V



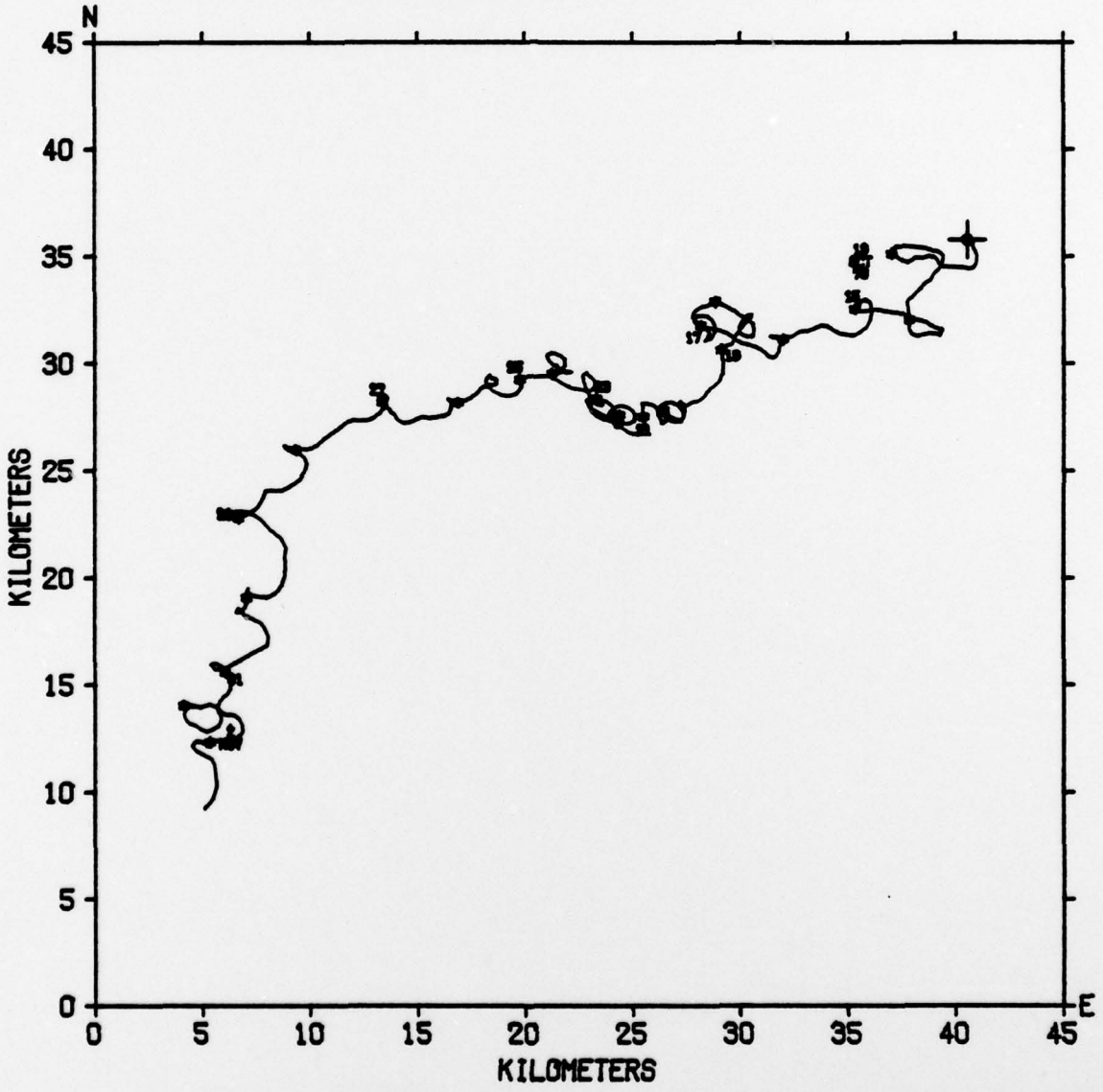


TIME SERIES OF VECTOR AVERAGED CURRENTS AT MDE,NISKIN CM 14
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 752 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 0145 1 NOV 76 (20.0 DAYS)
AVERAGING INTERVAL = 1.0 HOURS (4 POINTS)

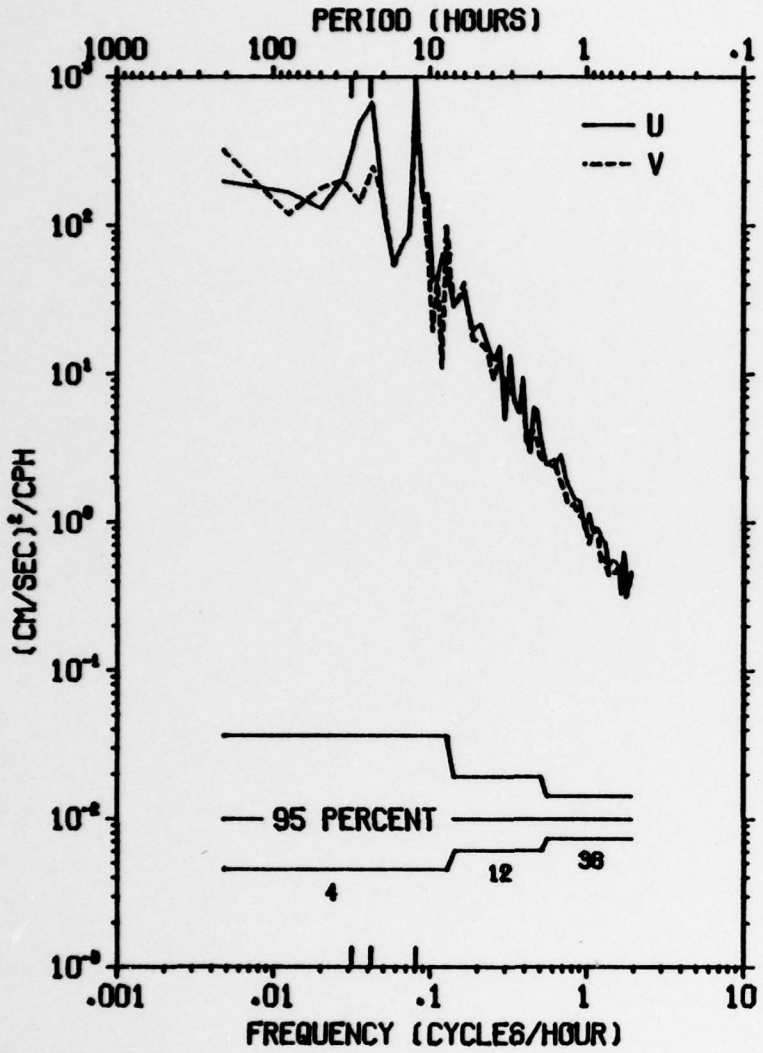


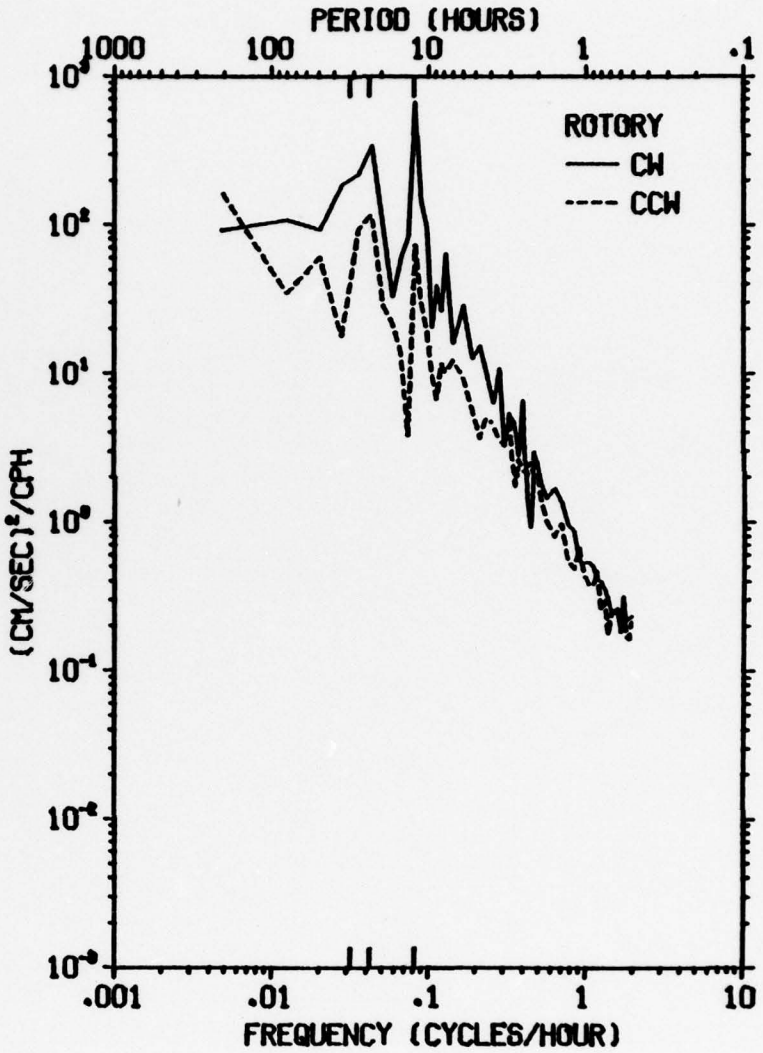

TIME SERIES OF VECTOR AVERAGED CURRENTS AT MDE.NISKIN CM 14
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 752 METERS
OBSERVATION PERIOD = 0200 1 NOV 76 TO 1945 2 NOV 76 (1.8 DAYS)
AVERAGING INTERVAL = 1.0 HOURS (4 POINTS)
SPEED (CM/SEC)
25
20
15
10
5
0
DIRECTION (DEGREES)
270
180
90
WEST EAST (CM/SEC)
20
10
0
-10
-20
SOUTH NORTH (CM/SEC)
20
10
0
-10
-20
WEST EAST (CM/SEC)
4.5
3.0
1.5
0.0
-1.5
-3.0
-4.5
2
NOV
76
5
10
15
20

PROGRESSIVE VECTOR DIAGRAM OF CURRENTS AT MDE.NISKIN CM 14
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 752 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
* EVERY 1.0 DAYS BEGINNING AT 0000 13 OCT 76

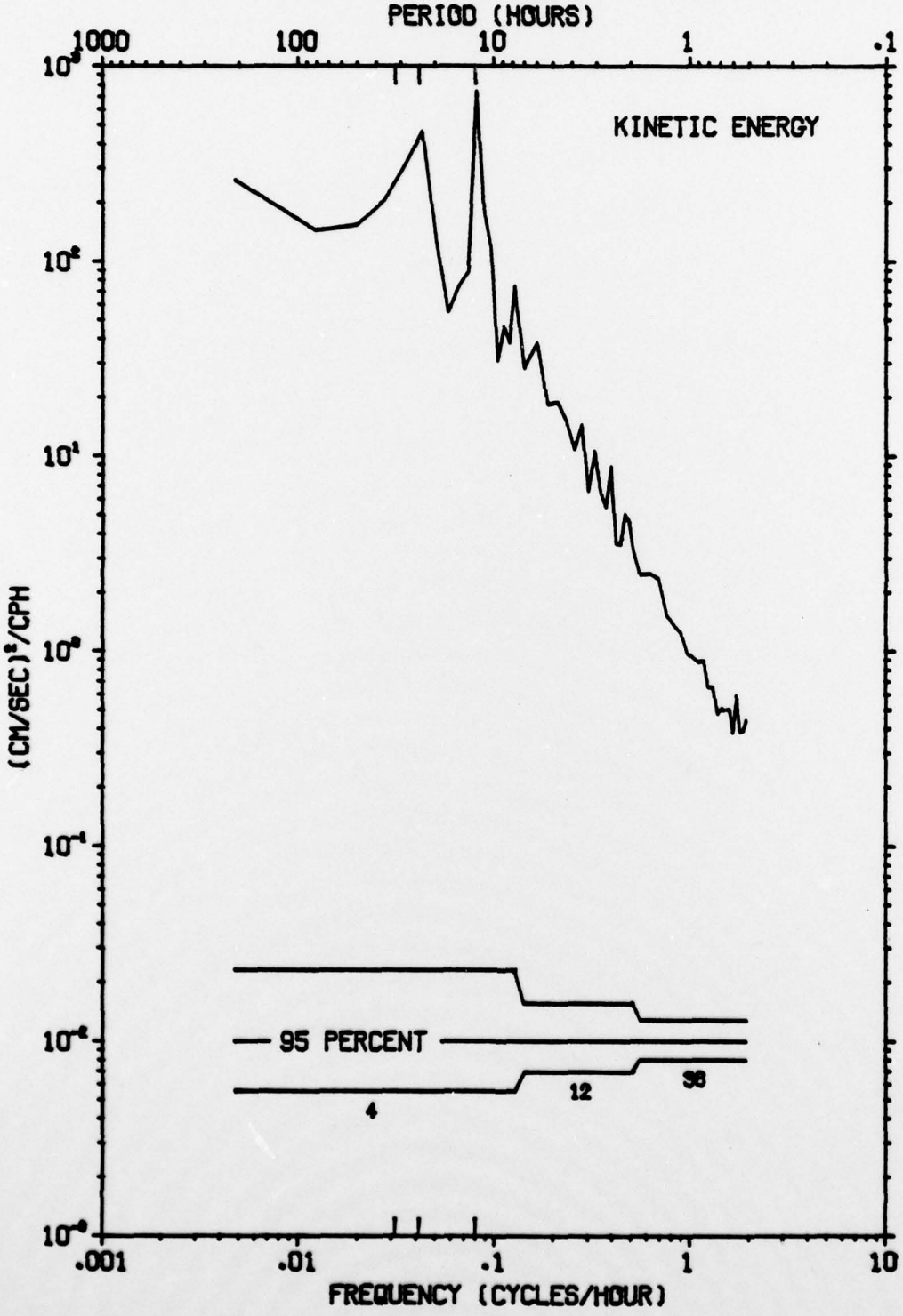


U. V AND ROTORY SPECTRA OF CURRENTS AT MDE.NISKIN CM 14
LOCATION = LAT 22 12.2N. LONG 159 56.8W. DEPTH = 752 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
N = 2088. DT = 15.00 MINUTES. SMOOTHING - DANIELL WINDOW





KINETIC ENERGY SPECTRUM OF CURRENTS AT MDE.NISKIN CM 14
LOCATION = LAT 22 12.2N. LONG 159 56.8W. DEPTH = 752 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
N = 2088. DT = 15.00 MINUTES. SMOOTHING - DANIELL WINDOW



APPENDIX B

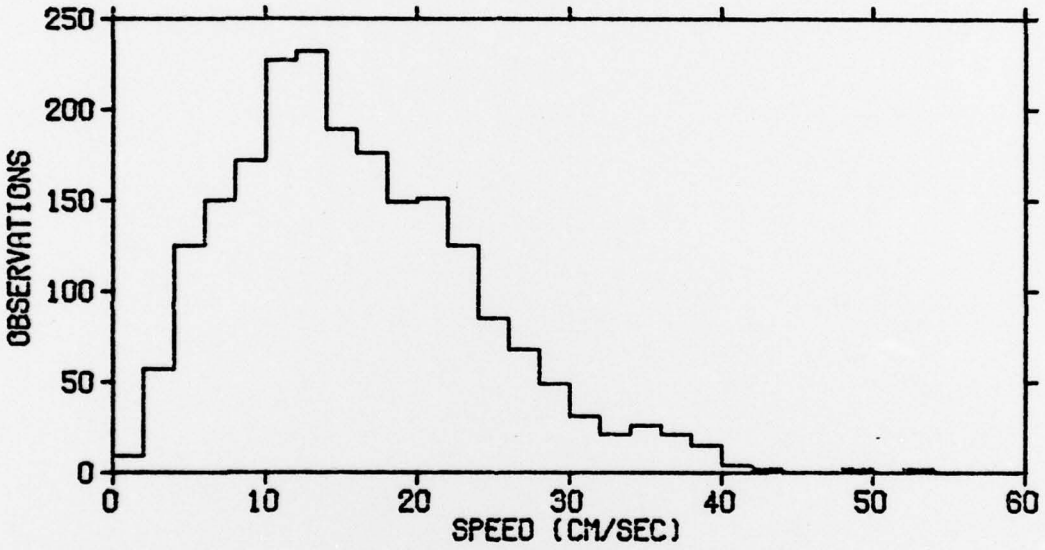
VACM

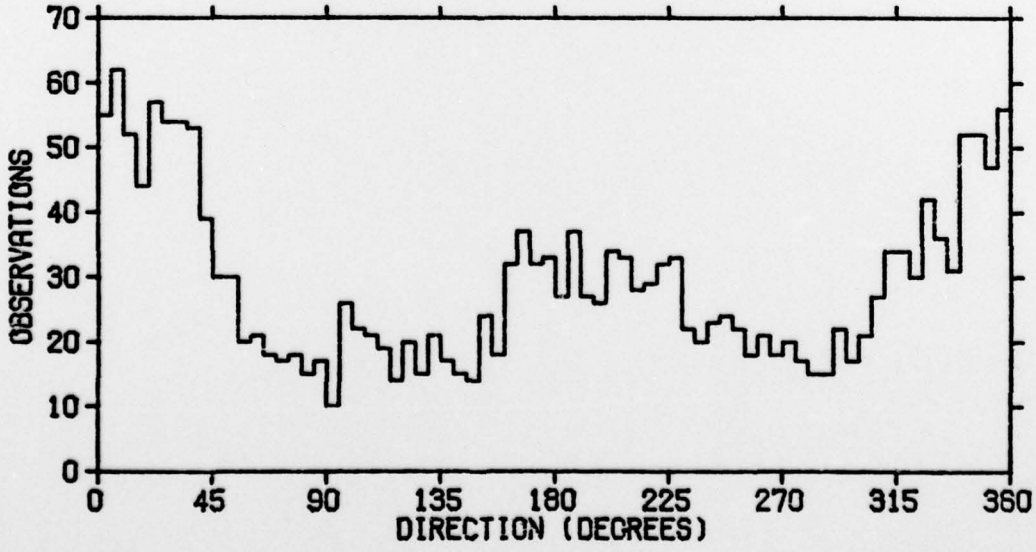
PROCESSED DATA

STATISTICS AND HISTOGRAMS OF CURRENTS AT MOORING DYN., V-0295
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 200 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
N = 2088, DT = 15.00 MINUTES, UNITS = (CM/SEC)

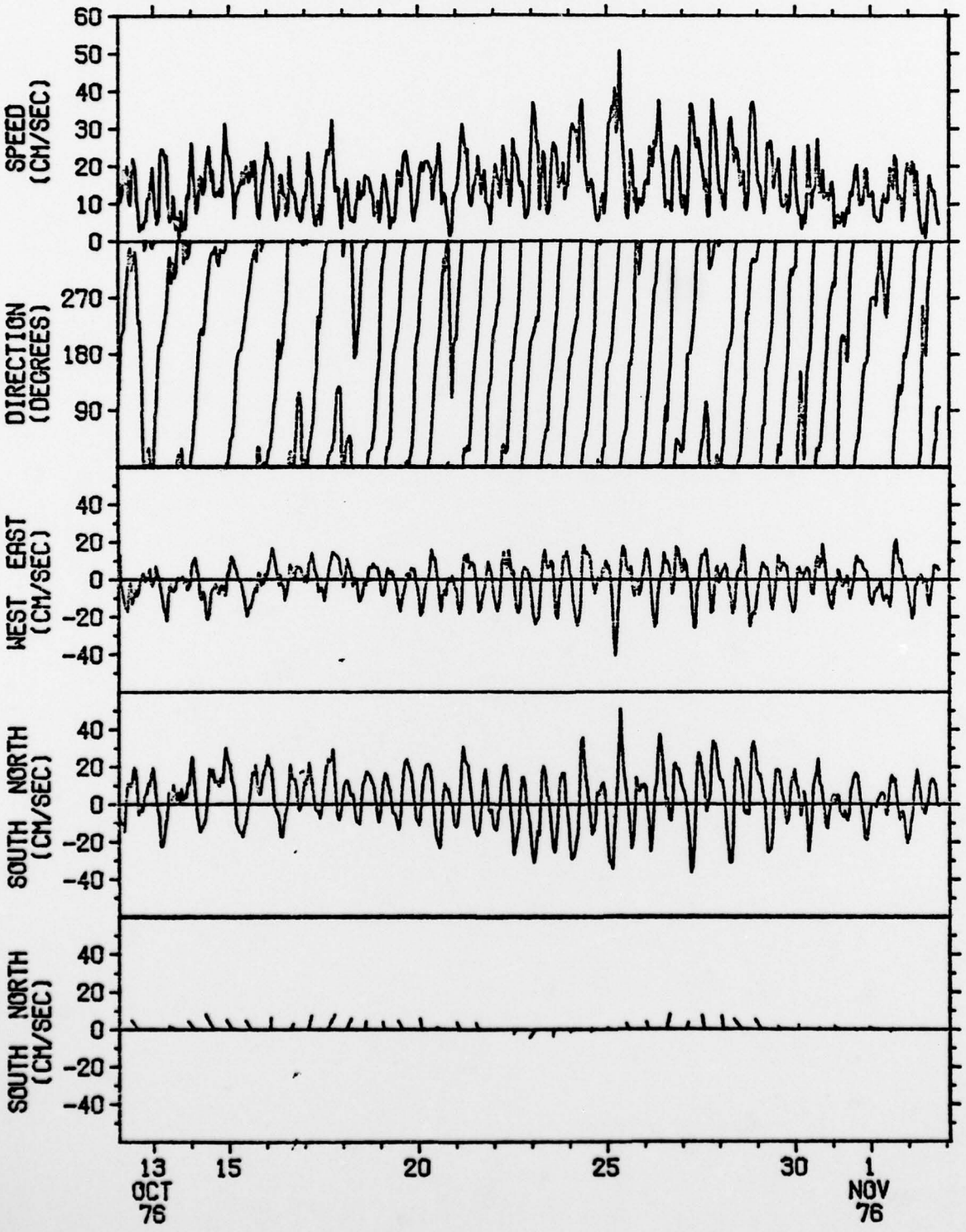
	MEAN	VARIANCE	ST-DEV	SKEW	KURT	MAX	MIN
S	15.99	66.50	8.15	.749	3.530	53.37	.55
U	-1.11	102.86	10.14	-.430	3.001	28.16	-43.00
V	3.03	208.77	14.45	-.174	2.836	53.31	-38.88

S = SPEED
U = EAST-WEST COMPONENT OF VELOCITY, EAST = POSITIVE U
V = NORTH-SOUTH COMPONENT OF VELOCITY, NORTH = POSITIVE V

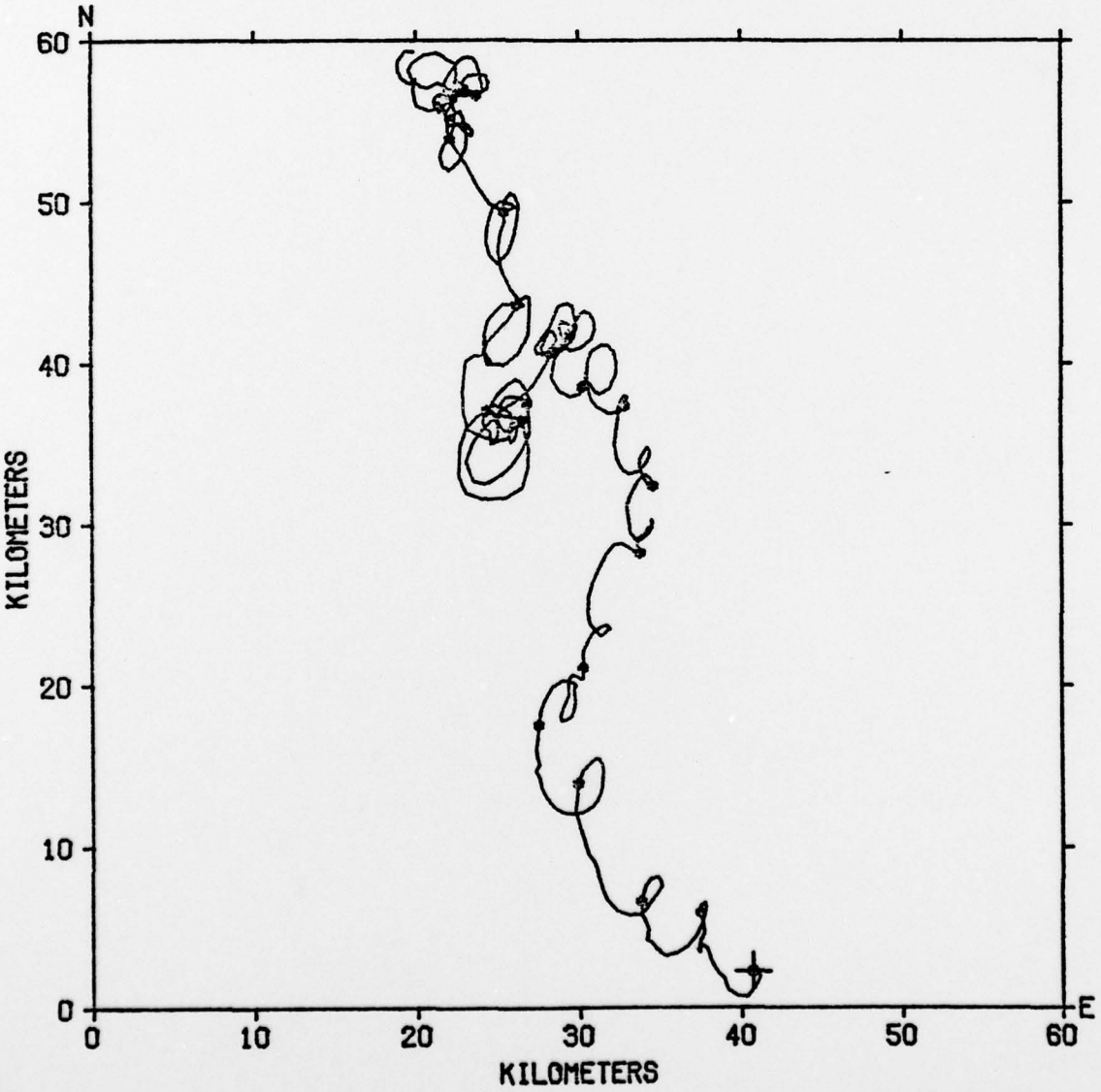




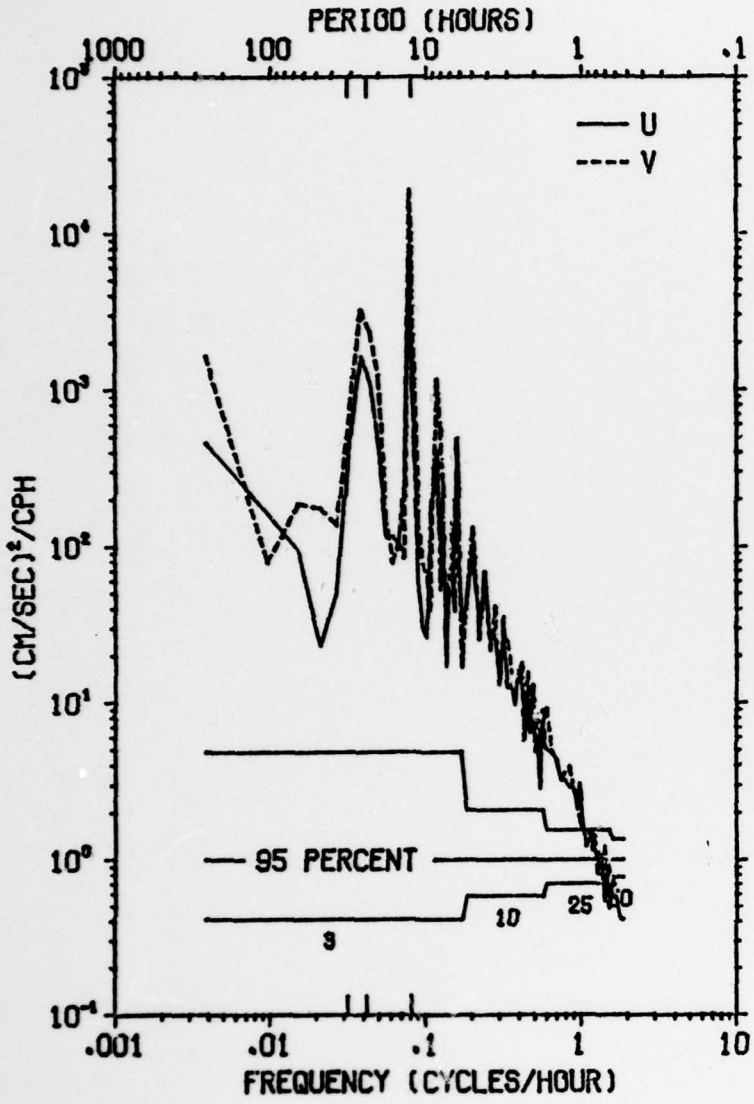
TIME SERIES OF VECTOR AVERAGED CURRENTS AT MOORING DYN., V-0295
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 200 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
AVERAGING INTERVAL = 1.0 HOURS (4 POINTS)

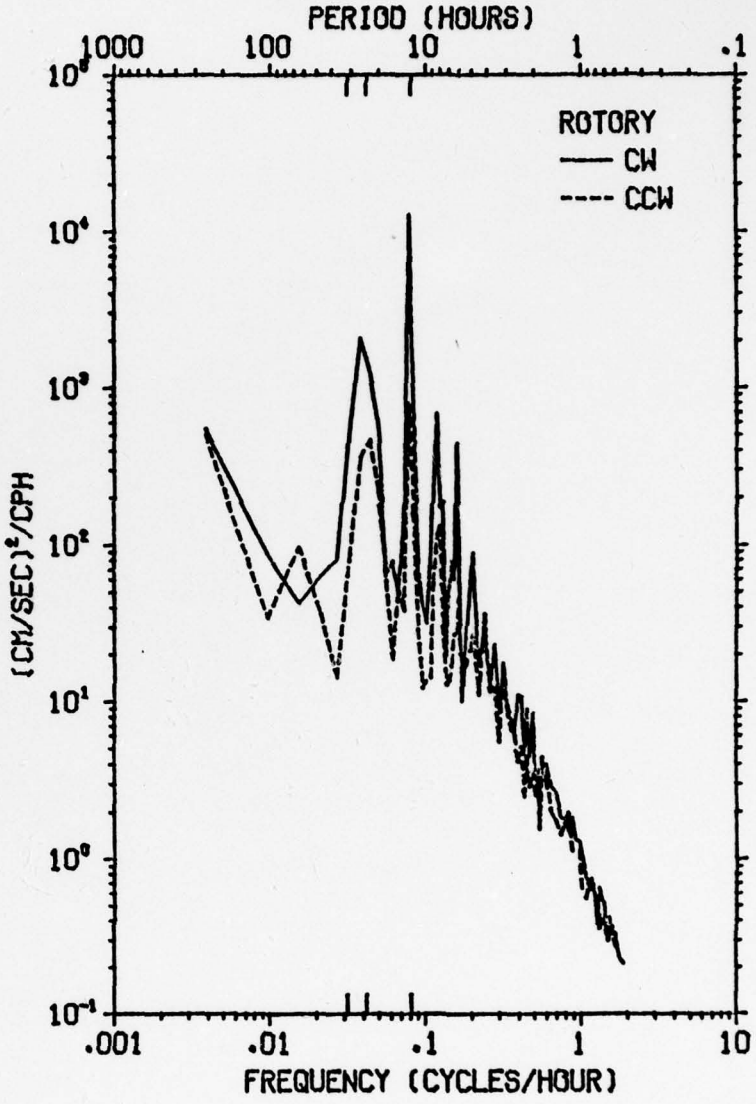


PROGRESSIVE VECTOR DIAGRAM OF CURRENTS AT MOORING DYN.. V-0295
LOCATION = LAT 22 12.2N. LONG 159 56.8W. DEPTH = 200 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
* EVERY 1.0 DAYS BEGINNING AT 0000 13 OCT 76

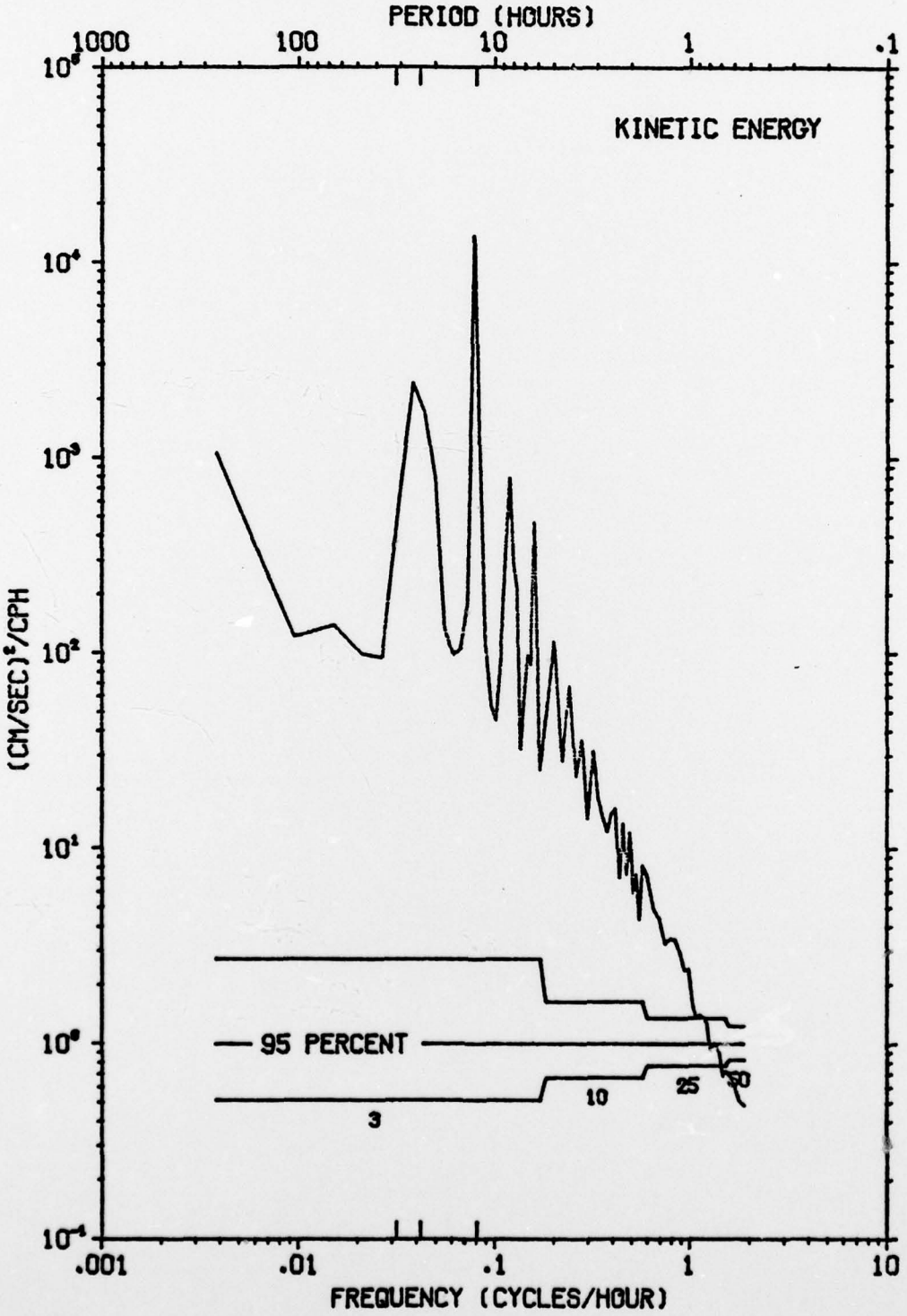


U, V AND ROTORY SPECTRA OF CURRENTS AT MOORING DYN., V-0295
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 200 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
N = 2068, DT = 15.00 MINUTES, SMOOTHING - DANIELL WINDOW





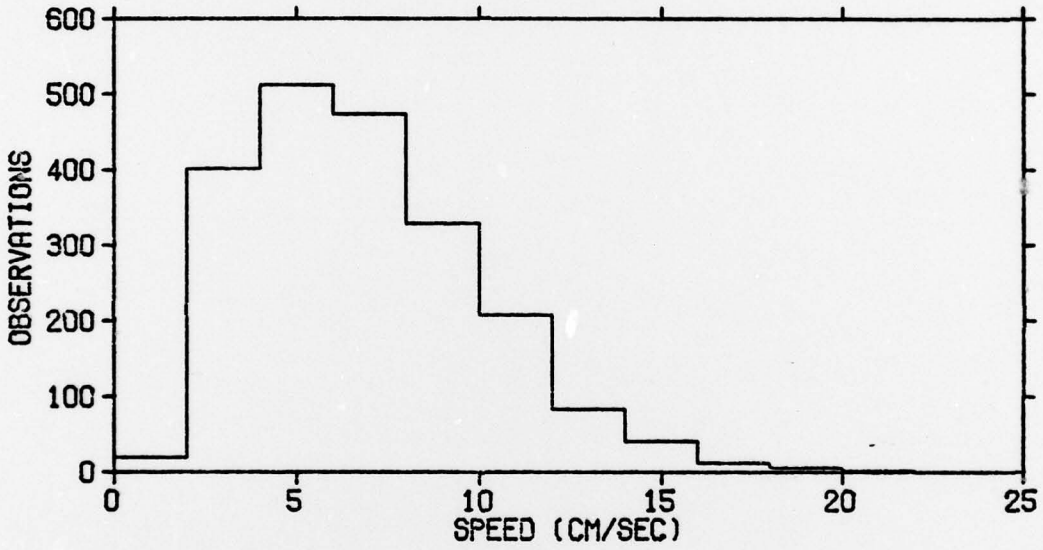
KINETIC ENERGY SPECTRUM OF CURRENTS AT MOORING DYN.. V-0295
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 200 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
N = 2088, DT = 15.00 MINUTES, SMOOTHING - DANIELL WINDOW

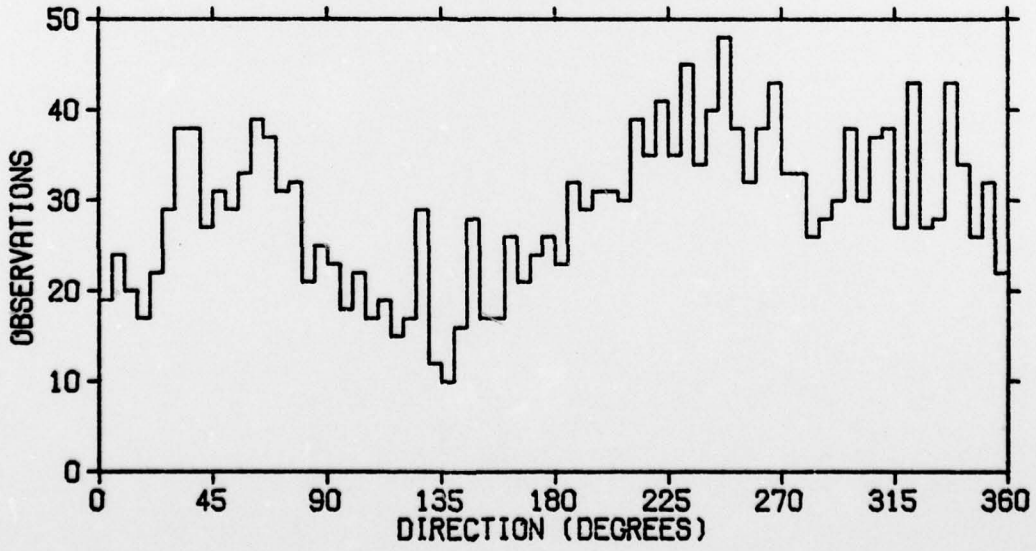


STATISTICS AND HISTOGRAMS OF CURRENTS AT MOORING DYN., V-0264
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 750 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
N = 2088, DT = 15.00 MINUTES, UNITS = (CM/SEC)

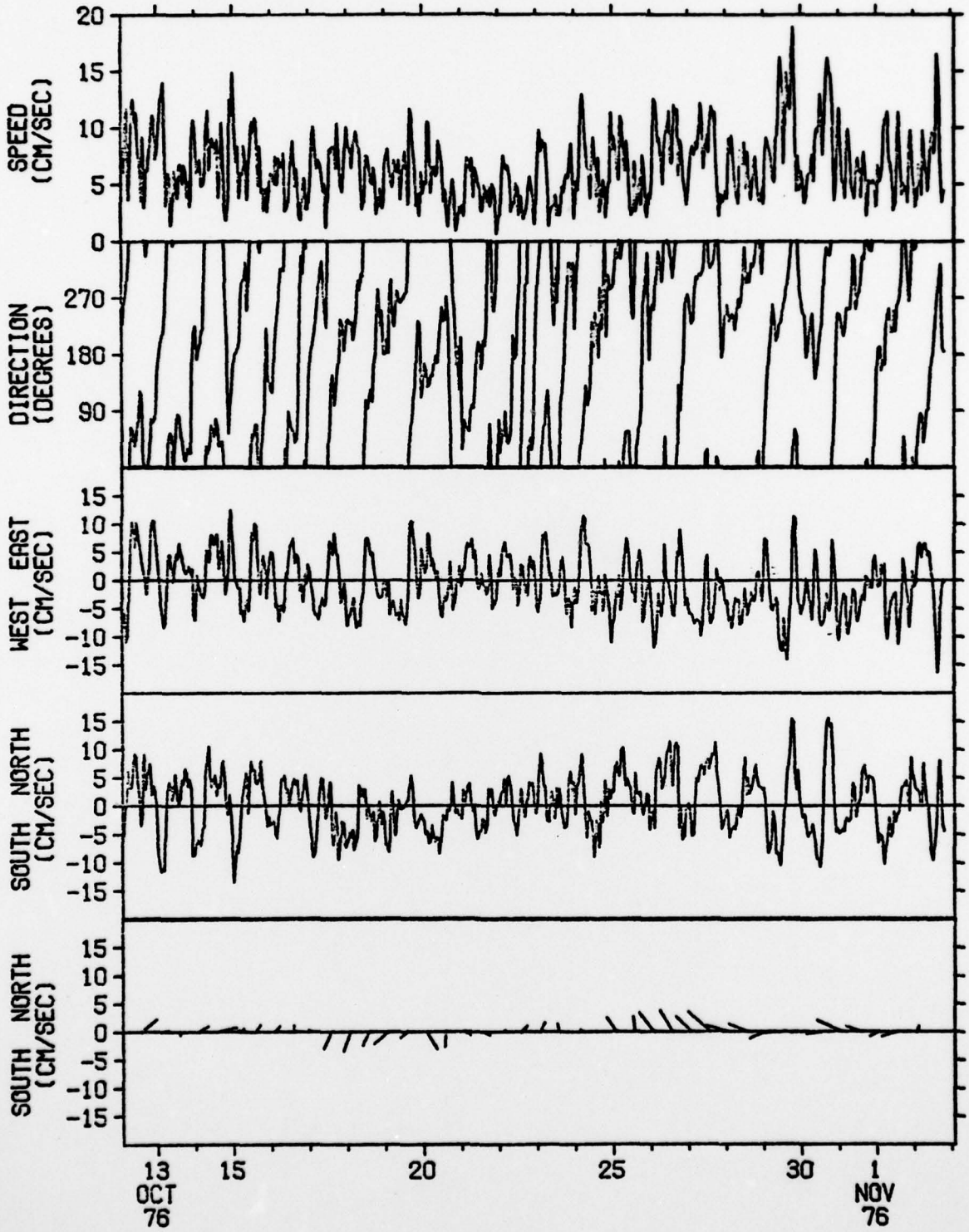
	MEAN	VARIANCE	ST-DEV	SKEW	KURT	MAX	MIN
S	6.90	10.00	3.16	.829	3.675	20.78	.13
U	-.78	28.67	5.35	.135	2.612	13.84	-20.73
V	.38	28.17	5.31	.125	2.866	18.17	-15.64

S = SPEED
U = EAST-WEST COMPONENT OF VELOCITY, EAST = POSITIVE U
V = NORTH-SOUTH COMPONENT OF VELOCITY, NORTH = POSITIVE V

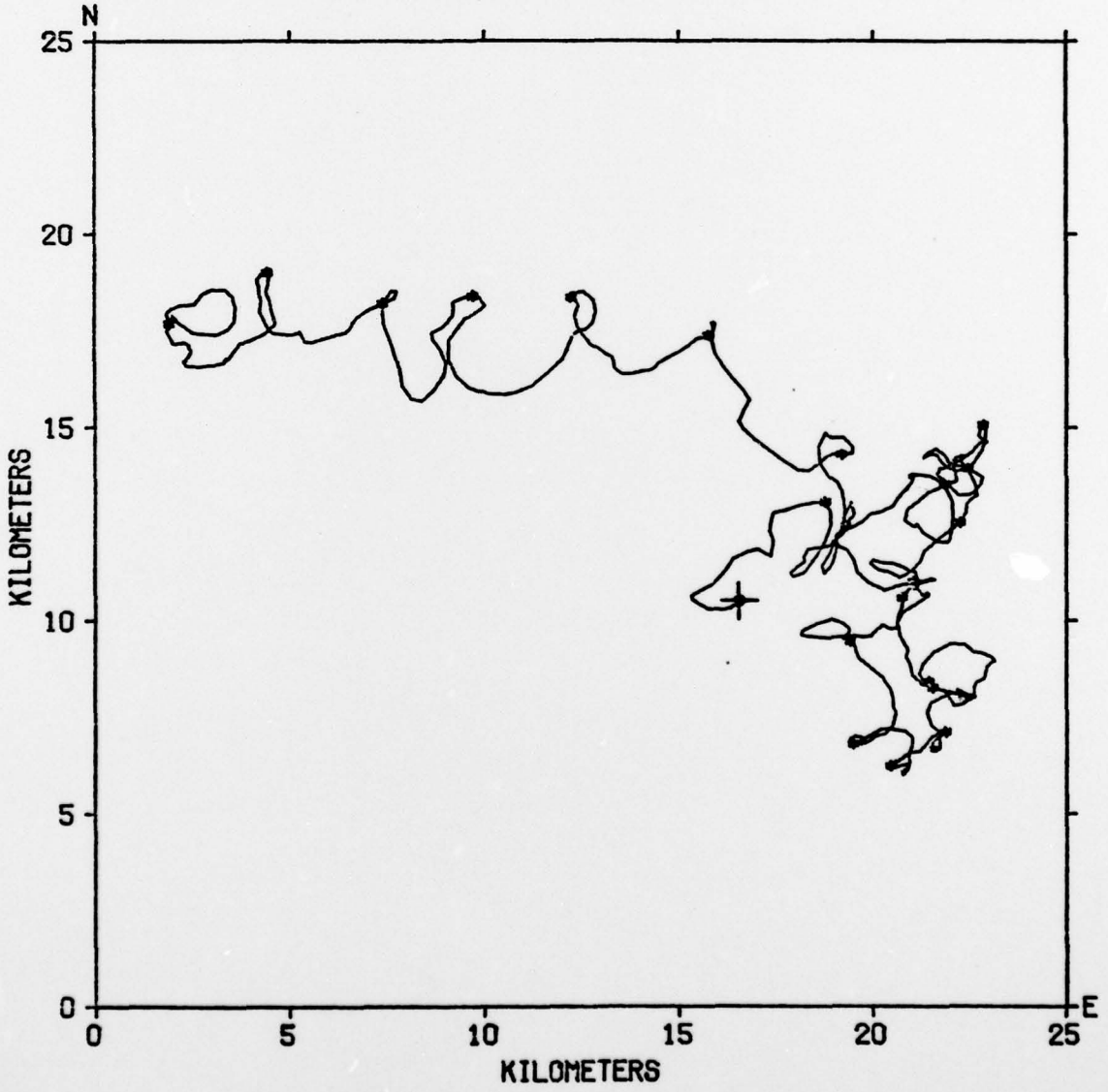




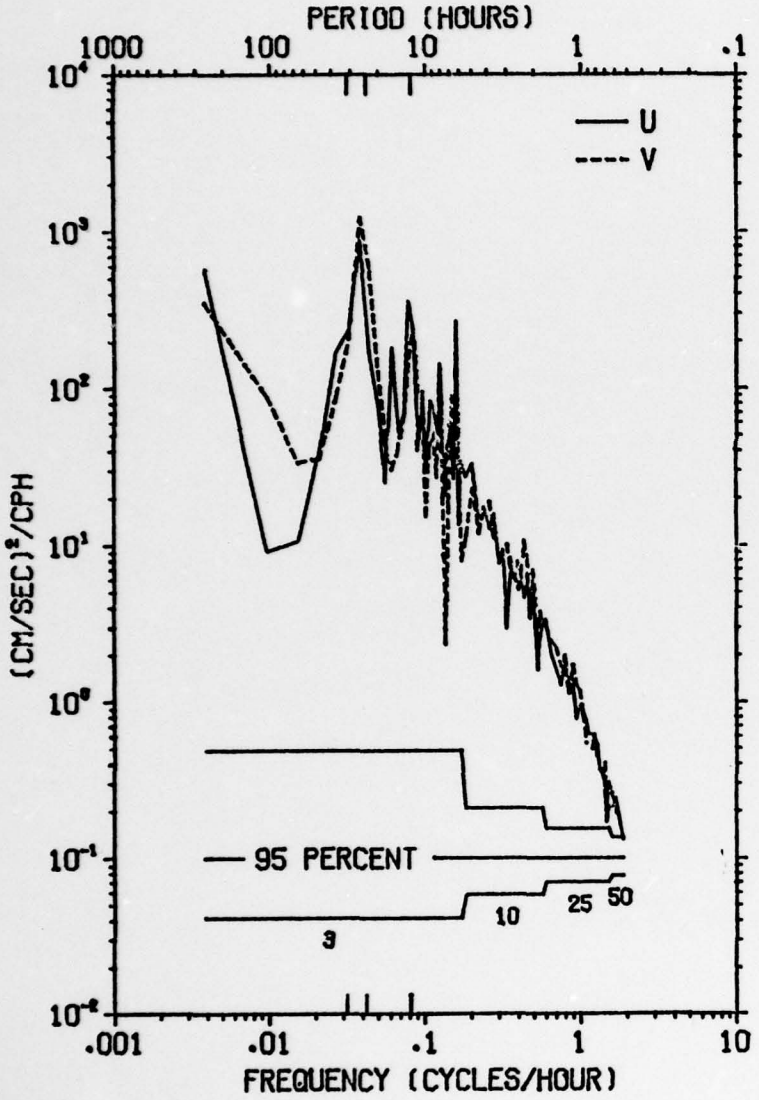
TIME SERIES OF VECTOR AVERAGED CURRENTS AT MOORING DYN., V-0264
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 750 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
AVERAGING INTERVAL = 1.0 HOURS (4 POINTS)

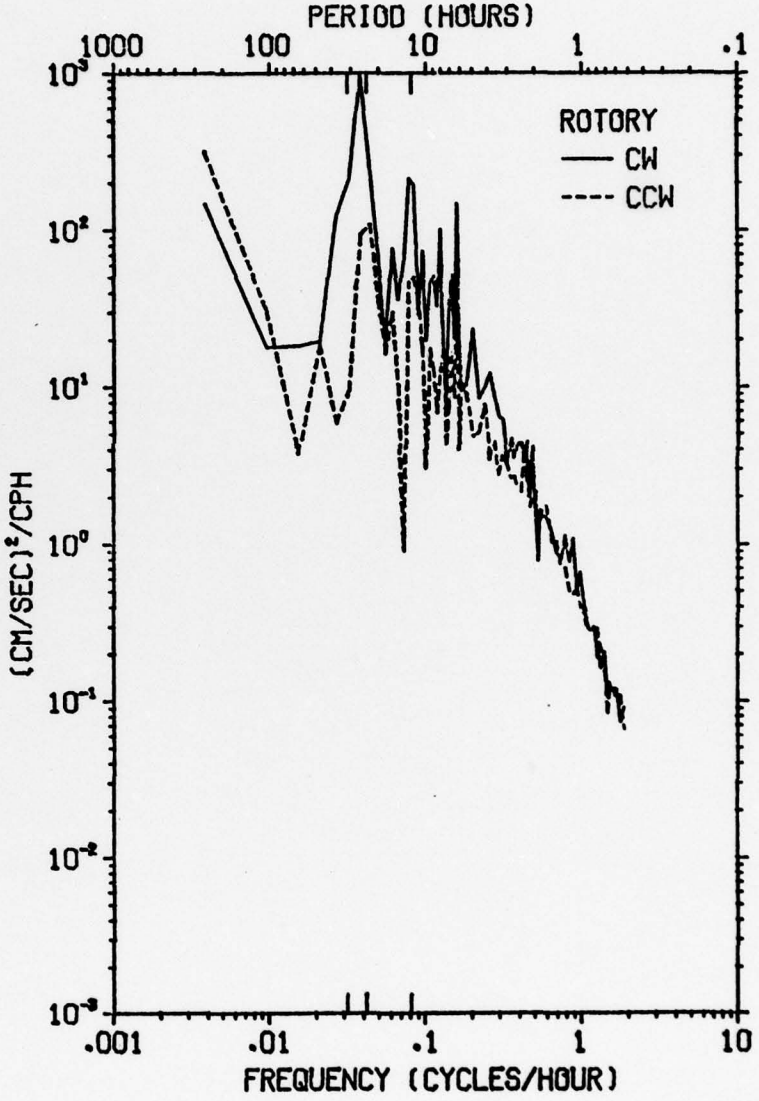


PROGRESSIVE VECTOR DIAGRAM OF CURRENTS AT MOORING DYN., V-0264
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 750 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
* EVERY 1.0 DAYS BEGINNING AT 0000 13 OCT 76



U, V AND ROTORY SPECTRA OF CURRENTS AT MOORING DYN., V-0264
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 750 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
N = 2088, DT = 15.00 MINUTES, SMOOTHING - DANIELL WINDOW





KINETIC ENERGY SPECTRUM OF CURRENTS AT MOORING DYN., V-0264
LOCATION = LAT 22 12.2N, LONG 159 56.8W, DEPTH = 750 METERS
OBSERVATION PERIOD = 0200 12 OCT 76 TO 1945 2 NOV 76 (21.7 DAYS)
N = 2088, DT = 15.00 MINUTES, SMOOTHING - DANIELL WINDOW